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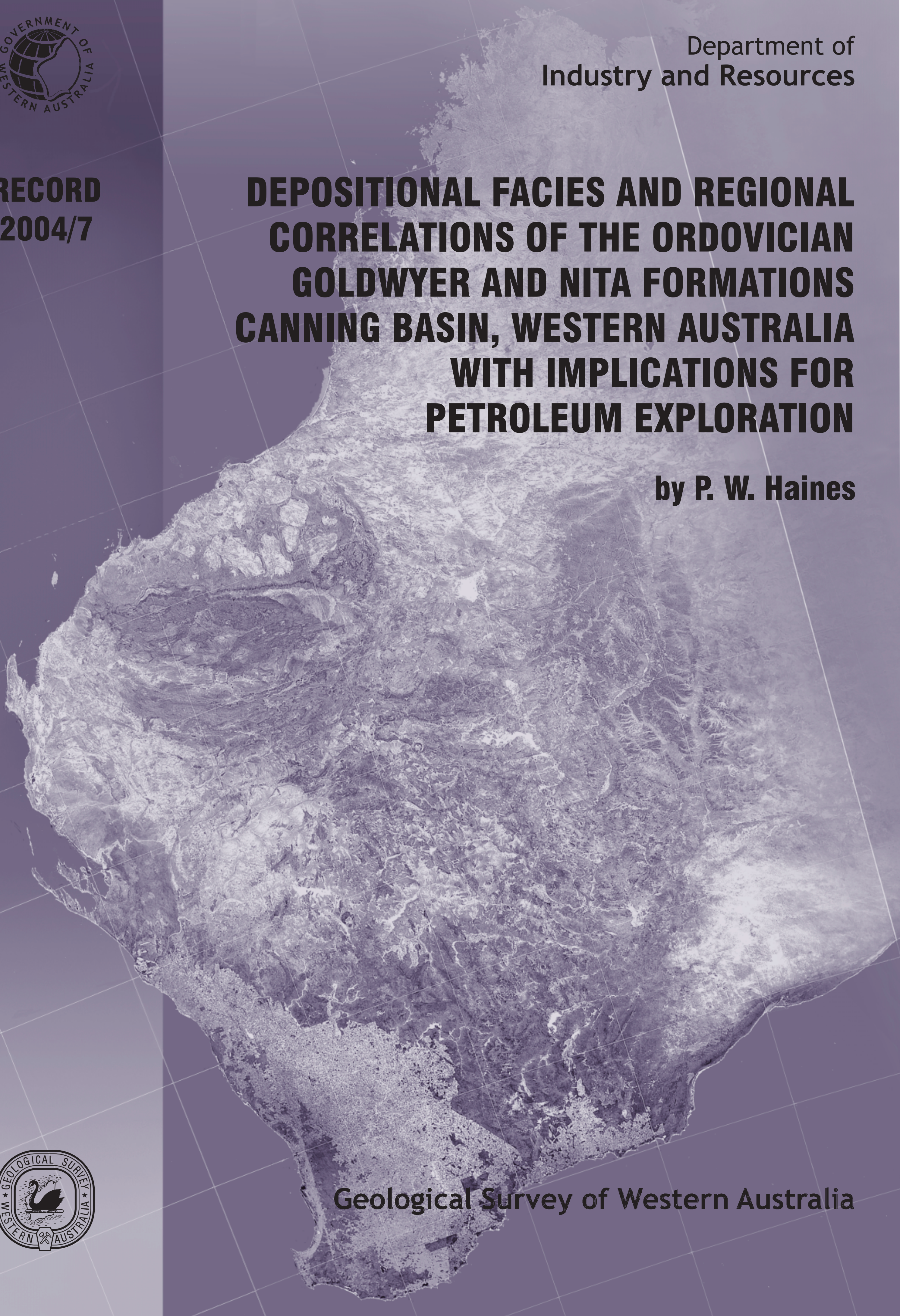
DEPOSITIONAL FACIES AND REGIONAL CORRELATIONS OF THE ORDOVICIAN GOLDWYER AND NITA FORMATIONS CANNING BASIN, WESTERN AUSTRALIA WITH IMPLICATIONS FOR PETROLEUM EXPLORATION

by P. W. Haines



GEOLOGICAL SURVEY WESTERN AUSTRALIA

Geological Survey of Western Australia

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P. W. Haines

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MINISTER FOR STATE DEVELOPMENT
Hon. Clive Brown MLA

DIRECTOR GENERAL, DEPARTMENT OF INDUSTRY AND RESOURCES
Jim Limerick

DIRECTOR, GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
Tim Griffin

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Contents

Abstract 1
Introduction 1
- Ordovician–Silurian stratigraphy of the Canning Basin 2
- Ordovician–Silurian biostratigraphy 5
- Ordovician–Silurian succession hydrocarbon potential 6
- Research methods 6

Goldwyer Formation 6
- Definition 6
- Lithofacies 6
- Wireline log characteristics and subdivision 7
- Depositional environment 9
- Hydrocarbon significance 9

Nita Formation 10
- Definition 10
- Lithofacies 10
- Wireline log characteristics and subdivision 12
- Depositional environment 12
- Hydrocarbon significance 12

Well correlations 14
Conclusions 14
References 15

Appendices

1. Petroleum exploration and stratigraphic wells intersecting the Nita and Goldwyer Formations 17
2. Selected mineral exploration drillholes intersecting the Nita and Goldwyer Formations 19
3. Formation tops and thickness data for selected wells 20
4. Explanatory notes for well correlation Plates 1–4 21
5. Graphic logs of selected drillcore 23

Plates

1. Stratigraphic correlations, Munro 1 to Hedonia 1 (Willara Sub-basin to Broome Platform)
2. Stratigraphic correlations, Frankenstein 1 to Crystal Creek 1 (Anketell Shelf to Mowla Terrace)
3. Stratigraphic correlations, Contention Heights 1 to Blackstone 1 (Ryan Shelf to Lennard Shelf)
4. Stratigraphic correlations, Kunzea 1 to Barbwire 1 (Broome Platform to Barbwire Terrace)

Figures

1. Principal structural elements of the Canning Basin 2
2. Location of petroleum wells and mineral exploration boreholes intersecting the Nita and Goldwyer Formations 3
3. Stratigraphic subdivision of the Ordovician–Silurian of the Canning Basin 4
4. Drillcore photographs from the Goldwyer and upper Willara Formations 8
5. Drillcore photographs from the Nita Formation 11
6. Location diagram for well correlation transects in Plates 1–4 13

Depositional facies and regional correlations of the Ordovician Goldwyer and Nita Formations, Canning Basin, Western Australia, with implications for petroleum exploration

by

P. W. Haines

Abstract

The Ordovician–Silurian stratigraphy of the subsurface onshore Canning Basin comprises the Nambeet, Willara, Goldwyer, and Nita Formations, deposited in various marine environments, and overlain by the evaporitic Carribuddy Group of marginal marine to non-marine origin. The Llanvirn (Middle Ordovician) Goldwyer and Nita Formations form an overall transgressive–regressive package of mudstone and carbonate, which locally host biohermal carbonate build-ups along fault scarps active in the Ordovician. Both formations show a pronounced facies cyclicity, particularly evident on wireline logs, related to small-scale shallowing-upward cycles superimposed on the formation-scale transgressive–regressive trends. The high-resolution correlation of individual cycles or groups of cycles possible on wireline log correlations suggests very low depositional slopes. Hydrocarbon shows have been widely reported in the Ordovician succession of the Canning Basin, most consistently within vuggy dolomitized carbonate beds of the Nita Formation. The Goldwyer Formation is reported to locally contain oil-prone *Gloeocapsomorpha prisca*-bearing source rocks, although the stratigraphic level is mostly immature for hydrocarbon generation based on conodont alteration indices. Biomarker characteristics of Canning Basin Ordovician oils have been used to link most to a *G. prisca* source, with the exception of biodegraded oils from the Nita Formation along the Admiral Bay Fault Zone, for which the inferred source is organic-rich mudstone horizons within the lower Carribuddy Group.

KEYWORDS: Canning Basin, Ordovician, Goldwyer Formation, Nita Formation, sedimentology, stratigraphy, biostratigraphy, petroleum.

Introduction

The Canning Basin in northern Western Australia is a predominantly onshore sedimentary basin covering an area of about 595 000 km^2. The basin preserves a long and complex multi-phase depositional history extending from the Early Ordovician to the Cainozoic (Forman and Wales, 1981; Brown et al., 1984; Kennard et al., 1994; Shaw et al., 1994). This Record focuses specifically on cored intersections of the Goldwyer and Nita Formations of Llanvirn (Middle Ordovician) age.

The Canning Basin is bounded by Proterozoic and Archaean domains and has been internally subdivided into a series of sub-basins, platforms, shelves, and terraces bounded by northwesterly–southeasterly trending fault systems, identified largely by geophysical means (Towner and Gibson, 1983; Purcell and Poll, 1984; Shaw et al., 1994). Principal tectonic domains illustrated in Figure 1 are after Tyler and Hocking (2001). At the broadest scale, the onshore Canning Basin can be subdivided into northern and southern provinces, separated by relatively thin successions on the contiguous mid-basin highs of the Broome (northwestern) and Crossland (southeastern) Platforms. To the north, very thick successions are preserved in the Fitzroy Trough (to the northwest) and Gregory Sub-basin (to the southeast), and to the south, thick successions are preserved in the Willara (northwestern) and Kidson (southeastern) Sub-basins. The Fitzroy Trough is flanked to the north by the Lennard Shelf, and to the south by the Jurgurra and Barbwire Terraces, transitional domains to the Broome and

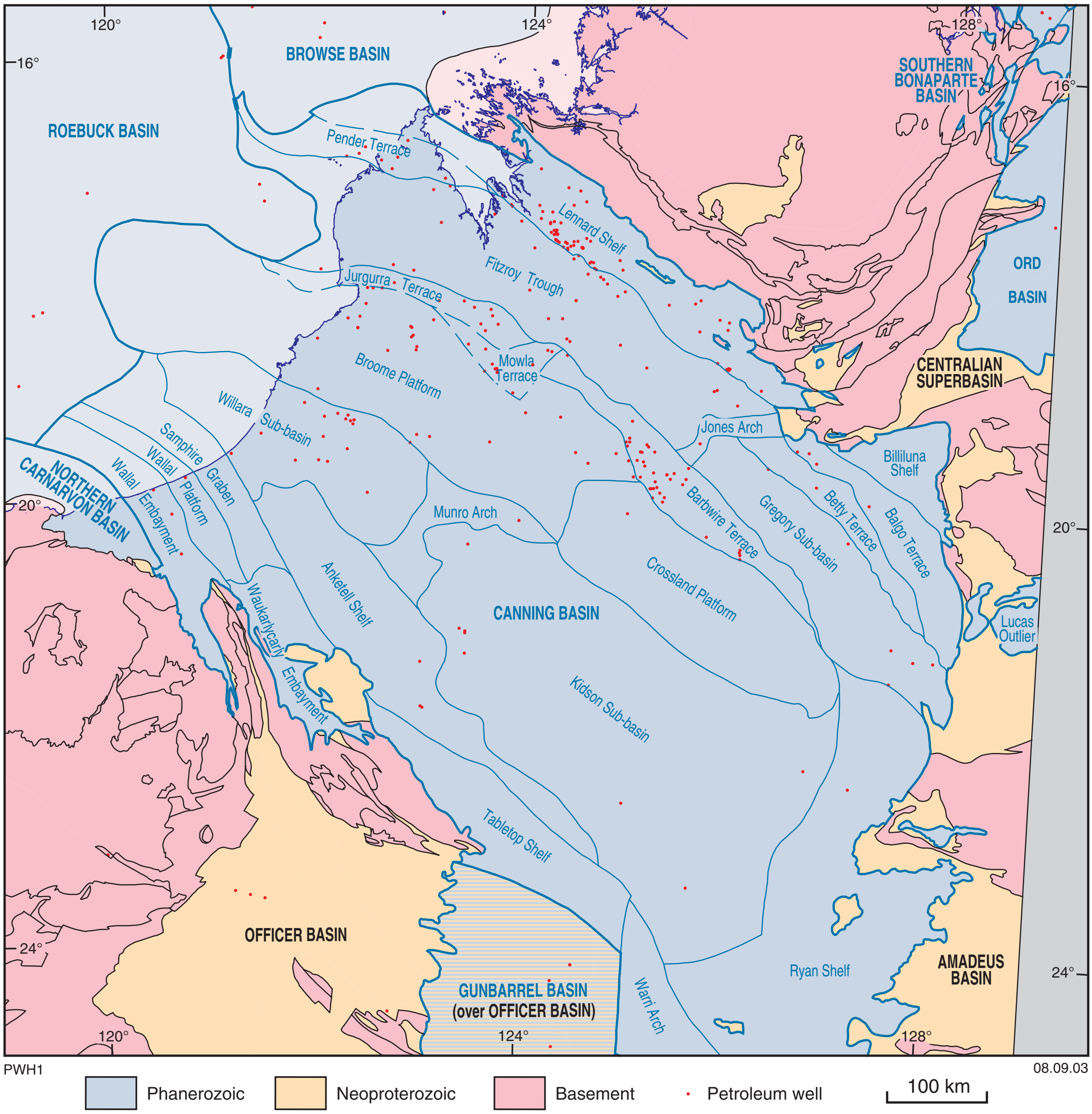


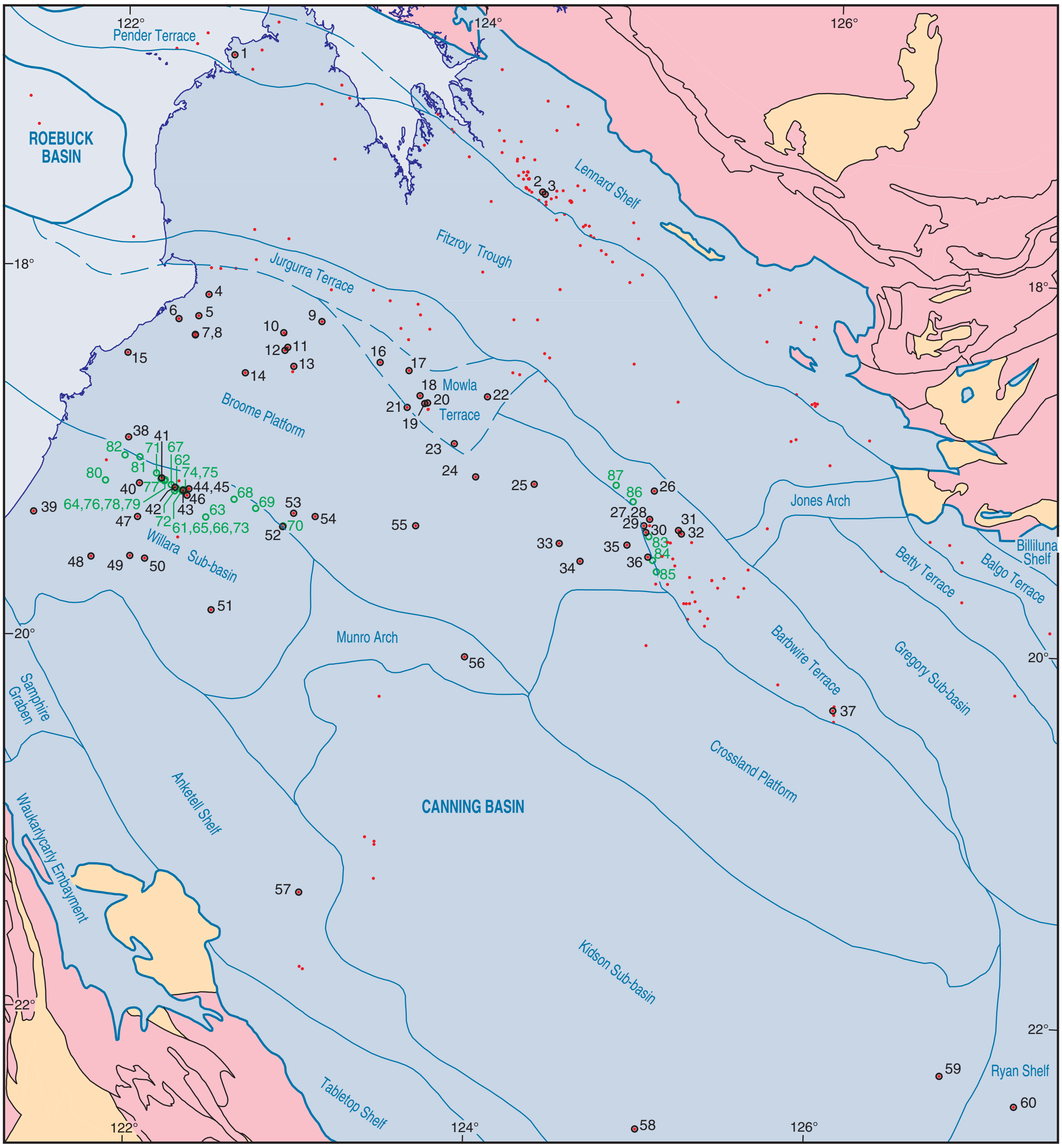
Figure 1. Principal structural elements of the Canning Basin

Crossland Platforms respectively. Relatively thin shelf successions are present south and east of the Willara and Kidson Sub-basins, most notably on the Anketell and Ryan Shelves.

The Ordovician Nita and Goldwyer Formations have been intersected in at least 60 petroleum exploration wells, and a number of mineral exploration drillholes (Fig. 2). The majority of these wells are on the Barbwire and Mowla Terraces, the Broome Platform and Willara Sub-basin, with isolated wells in the Kidson Sub-basin, and adjacent Anketell and Ryan Shelves. These formations are likely to be present at depth within the Fitzroy Trough and Gregory Sub-basin, but have not been intersected due to the great thicknesses of overlying units. Along the northern margin of the basin the Ordovician succession has mostly been eroded during a tectonic episode prior to the late Middle Devonian, being preserved only in isolated grabens.

Ordovician–Silurian stratigraphy of the Canning Basin

Deposition in the Canning Basin began in the Early Ordovician (Tremadoc) in response to extensional tectonics, and it is widely believed that the basin was connected to the Amadeus and other central Australian basins via the transcontinental Larapintine Seaway at this



Phanerozoic

Neoproterozoic

Basement

Petroleum well

24 Named petroleum well

68 Mineral exploration well

100 km

1 Tappers Inlet 1
2 West Blackstone 1
3 Blackstone 1
4 Roebuck Bay 1
5 Hedonia 1
6 Hilltop 1
7 Kanak 1
8 Goldwyer 1
9 Dampier Downs 1
10 Thangoo 1/1A
11 Thangoo 2
12 Sunshine 1
13 Twin Buttes 1
14 Aquila 1
15 Sharon Ann 1
16 Lovell's Pocket 1
17 Crystal Creek 1
18 Antares 1
19 Pictor 2
20 Pictor 1
21 Edgar Range 1
22 Matches Springs 1
23 Canopus 1
24 Looma 1
25 Robert 1
26 Barbwire 1
27 Acacia 1
28 Acacia 2
29 Solanum 1
30 Setaria 1
31 Dodonea 1
32 Dodonea 2
33 Fruitcake 1
34 Missing 1
35 Santalum 1A
36 Kunzea 1
37 Percival 1
38 Parda 1
39 Anna Plains 1
40 Willara 1
41 Nita Downs 1
42 Cudalgarra 2
43 Cudalgarra 1
44 Great Sandy 2
45 Great Sandy 1
46 Leo 1
47 Juno 1
48 Calamia 1
49 Woods Hills 1
50 Darriwell 1
51 Munro 1
52 Vela 1
53 Musca 1
54 Carina 1
55 McLarty 1
56 Pegasus 1
57 Frankenstein 1
58 Kidson 1
59 Wilson Cliffs 1
60 Contention Heights 1
61 DD86SS2 (CRAE)
62 DD86SS3 (CRAE)
63 DD87SS4(CRAE)
64 DD87SS6 (CRAE)
65 DD87SS7 (CRAE)
66 DD87SS8 (CRAE)
67 DD88SS9 (CRAE)
68 DD88SS10 (CRAE)
69 DD88SS11 (CRAE)
70 DD88SS12 (CRAE)
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76 DD89SS18 (CRAE)
77 DD90SS19 (CRAE)
78 DD90SS20 (CRAE)
79 DD90SS21 (CRAE)
80 DD91SS22 (CRAE)
81 DD90SS23 (CRAE)
82 DD91SS24 (CRAE)
83 BW1 (Pasminco)
84 BW3A (Pasminco)
85 BW5 (Pasminco)
86 BW21 (Pasminco)
87 BW26 (Pasminco)

Figure 2. Location of petroleum exploration wells and selected mineral exploration drillholes intersecting the Nita and Goldwyer Formations

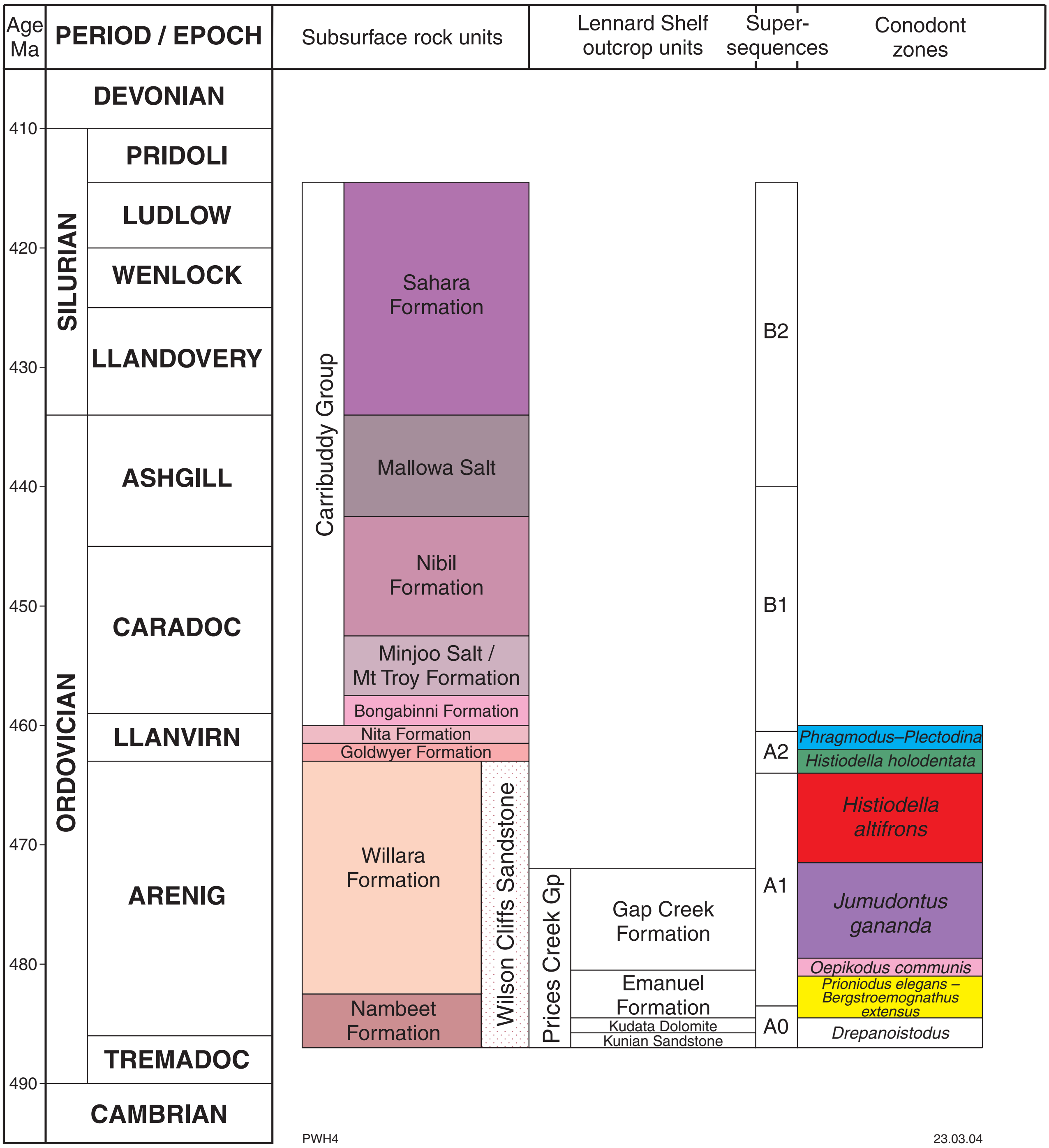


Figure 3. **Stratigraphic subdivision of the Ordovician–Silurian succession of the Canning Basin modified from Jones et al. (1998). Supersequence subdivision after Romine et al. (1994). Conodont zones after Nicoll et al. (1993)**

time (Nicoll et al., 1988; Cook and Totterdell, 1990). Apart from local erosional hiatuses, the Lower Ordovician to Lower Silurian succession is a relatively conformable package of sedimentary rocks deposited in marine, marginal marine, and terrestrial environments. The succession is overlain unconformably by Devonian, Carboniferous, or Permian strata, and variable proportions of the older package were removed by erosion prior to later depositional episodes. The main Ordovician–Silurian succession, which is not exposed in outcrop, is subdivided into the Lower–Middle Ordovician Nambeet, Willara, Goldwyer, and Nita Formations, in ascending order, overlain by the Middle Ordovician – Lower Silurian Carribuddy Group (McTavish and Legg, 1976; Nicoll et al., 1994; Fig. 3).

The Tremadocian (Lower Ordovician) Nambeet Formation contains a basal transgressive sandstone and conglomerate, succeeded by mudstone, limestone, dolostone, and sandstone of marine origin. The Nambeet

Formation is overlain, mostly conformably, by the Arenig to Llanvirn (Lower to Middle Ordovician) Willara Formation, which is commonly dominated by limestone, with subordinate dolostone, mudstone, and sandstone, of shallow marine origin. In some central and eastern areas the formation contains a significant central sandstone body, referred to informally as the 'Acacia sands' or 'Acacia sandstone member' (Little, 1992; King, 1998a,b). The proportion of sandstone increases to the southeast, where locally the Nambeet and Willara Formations are replaced by the coeval Wilson Cliffs Sandstone (McTavish and Legg, 1976).

The Willara Formation is overlain conformably by the Llanvirn (Middle Ordovician) Goldwyer Formation. The Goldwyer Formation is mainly of open marine to intertidal origin, varies from mudstone-dominated in basinal areas to limestone-dominated in some platform and terrace areas, and has locally undergone significant secondary dolomitization. The conformably overlying Llanvirn Nita Formation is a cyclical shallowing-upward unit of interbedded limestone, dolostone, and mudstone of tidal to supratidal origin. In the western part of the basin this formation has been subdivided into the Leo and Cudalgarra Members, separated by an exposure surface of at least local distribution (McCracken, 1994, 1997). The younger Cudalgarra Member is mostly of supratidal origin and contains evaporitic facies.

The Nita Formation is overlain by redbed evaporitic mudstone and minor carbonate and sandstone of the Bongabinni Formation, the basal unit of the Carribuddy Group. An erosional hiatus was inferred in this position by many earlier workers, necessitated by an assumed Devonian age for the Carribuddy Group. However, fully cored intersections of the contact now suggest a gradational relationship, and palynological (Foster and Williams, 1991) and conodont evidence (Nicoll et al., 1994) support an Ordovician to Early Silurian age range. The Carribuddy Group comprises in ascending order the Bongabinni Formation, Minjoo Salt and laterally equivalent Mount Troy Formation, Nibil Formation, Mallowa Salt, and Sahara Formation. Some marine influence is indicated by conodonts in the Sahara Formation (Nicoll et al., 1994), and the thick massive halite deposits (Minjoo and Mallowa Salt) suggest a marginal marine barred-basin setting. The complete Carribuddy Group is only preserved locally within sub-basin depocentres.

Small outcrops of Lower Ordovician rocks along the northeastern margin of the basin are assigned to the Prices Creek Group. This succession comprises transgressive sandstone (Kunian Sandstone), overlain by carbonate and mudstone of marine origin (Kudata Dolomite, Emanuel Formation, Gap Creek Formation), and is the same age as the Nambeet and lower Willara Formations, based on biostratigraphic data (Nicoll et al., 1993). The Prices Creek Group is overlain unconformably by Devonian strata, such that any younger components of the Ordovician–Silurian succession that once may have been present in this area have been removed by erosion.

Several sequence stratigraphic subdivisions of the Canning Basin have been attempted. Most recently, Kennard et al. (1994) and Romine et al. (1994) recognized the Ordovician–Silurian succession as the first of four first-order depositional megasequences. The Ordovician–Silurian megasequence is further subdivided into five supersequences, and numerous third-order sequences. The Goldwyer and Nita Formations are largely encapsulated within their supersequence A2, which extends from the upper part of the Willara Formation, to a position within the Nita Formation (probably coinciding with the Leo–Cudalgarra Member boundary). The upper part of the Nita Formation is assigned to their supersequence B1. The boundaries were picked using combined seismic and wireline data, although specific details are not provided. The lower and upper boundaries of the Ordovician–Silurian megasequence coincide with tectonic events: a basin-forming extensional episode at the base, and the Prices Creek Compressional Movement at the top, which resulted in folding and a regional unconformity. The megasequence shows an overall transgressive–regressive trend. The timing of peak transgression is inferred to coincide with shale deposition in supersequence A2, corresponding to the lower Goldwyer Formation (Romine et al., 1994). McCracken (1997) recognized six third-order sequences within supersequence A2 in the Admiral Bay Fault Zone area. This region was tectonically active during sedimentation of the Goldwyer and Nita Formations, which raises doubts as to the regional applicability of this subdivision scheme.

Ordovician–Silurian biostratigraphy

The pre-Carribuddy Group succession contains abundant and well-preserved macro- and microfossil assemblages. Detailed studies have been carried out on trilobites (Legg, 1976; Laurie, 1997), graptolites (McTavish and Legg, 1972; Legg, 1976; Skwarko, 1967, 1974), brachiopods (Laurie, 1997), large organic-walled microfossils (chitinozoans, scolecodonts, hydrozoans, and foraminiferal linings; Foster et al., 1999; Winchester-Seeto et al., 2000) and conodonts (McTavish and Legg, 1972; Nicoll, 1984; Watson, 1988; Nicoll, 1993; Nicoll et al., 1993; Nicoll et al., 1994). Of these groups, conodonts have proved the most useful for correlation with other Australian Ordovician basins, and can also provide a basis for formation-scale well correlation within the basin. The conodont zonation for the Ordovician of the Canning Basin is presented in Nicoll (1993), Nicoll et al. (1993), and Jones et al. (1998), and is summarized in Figure 3. Of particular relevance to this study are the *Phragmodus–Plectodina* Zone (Nita Formation and upper Goldwyer Formation) and *Histiodella holodentata* Zone (middle Goldwyer to upper Willara Formations). Data provided by Nicoll (1993) have been used extensively to assist well correlation for this study. Among the macrofossils, trilobites and graptolites have allowed the recognition of three faunal assemblages across the time interval represented by the Nita and Goldwyer Formations (Legg, 1978). The Carribuddy Group is largely devoid of age-diagnostic fossils with the exception of Late Ordovician – Early Silurian palynomorphs from the Mallowa Salt (Foster and Williams, 1991) and Early Silurian conodonts from the Sahara Formation (Nicoll et al., 1994).

Ordovician–Silurian succession hydrocarbon potential

In terms of age and general characteristics, the Ordovician of the Canning Basin belongs to the Larapintine 2 petroleum system of Bradshaw (1993). Although no commercial fields have been discovered in the Ordovician, the succession has been the primary or secondary objective of numerous exploration wells, encouraged by the presence of horizons reported to have excellent source-rock potential (Foster et al., 1986; Edwards et al., 1997), and numerous oil and gas shows. The most significant discovery to date has been in Pictor 1, which flowed 6.2 $\times 10^4$ m^3 of gas (2.2 MMcf) and 3.8 kL (24 bbl) of 45° API oil per day on a production test in the Nita Formation (BHP Petroleum, 1984).

Potential source rocks of varying quality have been reported from the Nambeet, Goldwyer, Bongabinni, and Sahara Formations (Burne et al., 1979; Foster et al., 1986; Kennard et al., 1994; Edwards et al., 1995, 1997). Edwards et al. (1997) considered the source-rock potential of the Nambeet Formation to be limited, and downgraded it with respect to previous reports, such as those in Kennard et al. (1994), due to the identification of drilling contaminants and migrated petroleum. In contrast, the Goldwyer Formation locally contains horizons with high concentrations of the marine alga *Gloeocapsomorpha prisca*, considered to have excellent source-rock potential (Foster et al., 1986; Edwards et al., 1997). Similar *G. prisca*-bearing source rocks are claimed to be responsible for commercial accumulations of hydrocarbons in the Amadeus, Baltic, Michigan–Illinois, and Williston Basins, each of which, including the Canning Basin, lay within 5° of the equator during the Ordovician (Foster et al., 1986). Oil-prone organic-rich calcareous mudstone beds with total organic carbon (TOC) values between 9% and 54.3% have been reported from the Bongabinni Formation near the Admiral Bay lead–zinc–silver deposit (Taylor, 1992; Edwards et al., 1995; McCracken, 1997).

Petroleum shows have been reported at numerous stratigraphic levels in the Ordovician–Silurian section, the most consistent position of which coincides with dolomitized carbonate rocks of the Nita Formation. Consequently, this unit has been repeatedly targeted as a potential reservoir. Although more restricted in distribution, the ‘Acacia sandstone member’ of the Willara Formation also exhibits reservoir potential and has been associated with significant hydrocarbon shows (Little, 1992; King, 1998a,b). Mudstone and tight carbonate throughout the Ordovician–Silurian succession, and massive evaporites in the Carribuddy Group, are considered to have the potential to act as seals, although detailed analysis has not been reported.

Research methods

This study of the Nita and Goldwyer Formations involved the examination and re-logging of selected fully cored petroleum and mineral exploration drillholes, and the examination of some shorter conventional petroleum exploration drillcores. Lithofacies were identified macroscopically, and interpreted in terms of primary depositional environments. Interpretations were compared with previous studies, some based to varying degrees on microfacies and palaeontology/palynology. Because most wells have little or no drillcore, a combination of wireline and interpretive lithological logs were used to infer correlations and broad facies trends across the basin (Plates 1–4). During this process, previously assigned formation tops in selected petroleum wells were reassessed, in conjunction with available biostratigraphic data, which in some cases led to significant changes in the inferred position of formation boundaries. Such methods were also used to extend the distribution of two members of the Nita Formation previously recognized by McCracken (1994) along the Admiral Bay Fault Zone, which separates the Willara Sub-basin and Broome Platform.

Goldwyer Formation

Definition

The stratotype of the Goldwyer Formation is the interval 848–1060 m (2782–3477 feet) in Thangoo 1A (Elliot, 1961; Burne et al., 1981). Drillcore is limited from this well, and the top of the formation has been removed by erosion prior to deposition of the Permian Grant Group. As such, it is difficult to use this well as a standard for regional correlation or facies analyses, and two additional wells are here nominated as reference sections. These are Solanum 1 (283–563 m; Plate 4; Appendix 5) on the Barbwire Terrace, and CRAE mineral exploration drillhole DD87SS7 (1546–1780 m; Appendix 5) in the Admiral Bay Fault Zone. Both are fully cored through the Goldwyer Formation, have complete wireline logs, and are archived in the Geological Survey of Western Australia core library in Perth. DD87SS7 is also the stratotype for two members of the Nita Formation (McCracken, 1994). The Goldwyer Formation has an average thickness of about 400 m. The thickest known intersection is in Blackstone 1 on the Lennard Shelf, which reached total depth within the formation. The incomplete intersection in this well is here inferred to be 739 m, although the stratigraphic position of the top contact with the Nita Formation is tentative (see discussion in Appendix 4). The thickest complete intersection is 736 m in Willara 1 in the Willara Sub-basin. Chronostratigraphy is based largely on conodonts, with the Goldwyer Formation ranging from the upper *Histiodella holodentata* Zone to the lower *Phragmodus–Plectodina* Zone, indicating an early Llanvirn age (Nicoll, 1993; Nicoll et al., 1993; Jones et al., 1998).

Lithofacies

The Goldwyer Formation is dominated by mudstone and carbonate, with ratios of these components varying widely across the basin. Major carbonate build-ups are present locally. Coarser siliciclastic rocks are generally absent or restricted to minor fine-grained sandstone, which increases in abundance towards the southeastern margin of the basin.

Goldwyer Formation mudstone varies in average grain size from claystone to siltstone. It is always chemically reduced, varying in colour from grey-green to grey and black, and is commonly sparsely pyritic. These rocks are commonly weakly to strongly calcareous or dolomitic, and in places contain millimetre-scale carbonate laminae. Bioturbation is locally present, and ranges from discrete cylindrical and branching burrow systems, to general 'churning' of the sediment. It is mainly restricted to rocks with grey-green or pale to medium grey colouration, and is typically absent from black mudstone or carbonate, due presumably to the presence of anoxic bottom conditions.

All carbonate appears to have been deposited originally as limestone, although significant diagenetic dolomitization has taken place in some areas. Limestone beds are typically pale to medium grey, and slightly pyritic. Most limestone is wackestone, with lesser amounts of packstone and grainstone. Allochems are dominated by bioclasts, but also include peloids, intraclasts, and locally ooids, pisoids and oncoids (Fig. 4d). Bioturbation is common, but not readily visible, unless the burrows are filled with material of different composition from the host bed, or selectively dolomitized (Fig. 4e). Primary fabrics are commonly partially destroyed by a well-developed diagenetic stylonodular fabric in which pods or lenticular layers of relatively pure limestone several centimetres in thickness are enveloped by more argillaceous stylolitic layers. Carbonate to mudstone ratios vary widely, but as a general rule the successions in deeper basinal areas are mudstone-dominated, and those on platforms and terraces have higher carbonate-to-mudstone ratios and in some areas are carbonate-dominated.

Macrofossils are locally present in the mudstone facies, most notably including trilobites, brachiopods, and less commonly graptolites and nautiloids. These are commonly intact and well preserved (whole brachiopod valves, whole trilobite moult segments, and rarely complete trilobites; Fig. 4b,c). Macrofossils are generally abundant in carbonate rocks, except where destroyed by pervasive dolomitization, and are represented by a diversity of trilobites, brachiopods, gastropods, bivalves, nautiloids, ostracods, bryozoans, and echinoderms. In contrast to mudstone facies, the macrofossils in carbonate beds are commonly fragmentary.

The Goldwyer Formation is notable for its cyclicity on a scale of several metres to several tens of metres. Cyclicity is best developed in platformal areas, and is evident most clearly on gamma-ray and sonic logs, due to the alternation in argillaceous content. A typical cycle in platform/terrace areas, as seen in the fully cored Barbwire Terrace wells, has a lower laminated mudstone interval which grades upwards through thin limestone interbeds, to a unit of stylonodular wackestone, with lesser amounts of packstone or locally grainstone at, or near, the top (Fig. 4f). This is then either sharply or gradationally overlain by laminated mudstone of the next cycle.

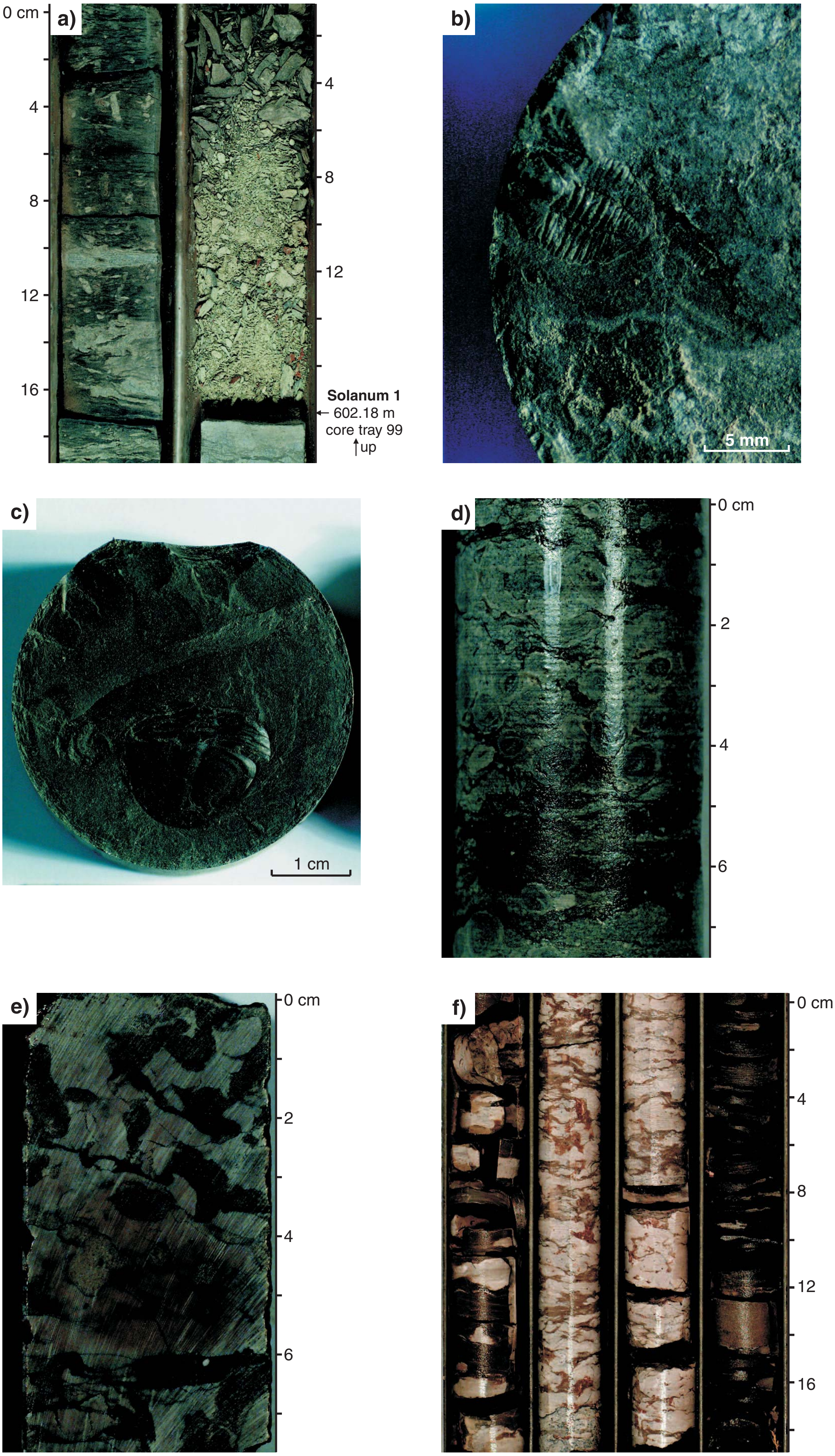
Along the Admiral Bay Fault Zone, the normal mudstone and interbedded limestone of the Goldwyer Formation is locally replaced by massive carbonate build-ups (the 'Admiral Bay carbonate group' of Russell and Edwards, 1984). These are extensively altered by mineralized vein systems (McCracken, 1994, 1997; McCracken et al., 1996), and have not been reported elsewhere in the basin. Individual build-ups reach 350 m in thickness and are up to 500 m wide. Relics of primary lithologies reveal domal and digitate stromatolites interbedded with intraclastic and bioclastic grainstone. The bioclastic grainstone contains an abundance of bryozoan remains (McCracken, 1997). Nearby wells display a dominantly mudstone succession, with interbeds of bioclastic grainstone apparently derived from the adjacent carbonate build-up.

Three thin (1–3 cm) green clay-rich beds in the lower Goldwyer Formation at 1726.5, 1745.2, and 1756.5 m in DD87SS7 (see Appendix 5) are probably tuffs. A similar, thicker bed is present in the upper Willara Formation in Solanum 1 (602.18 m; Fig. 4a), coincident with a sharp spike on the gamma-ray log. The implications for regional correlations are discussed below.

Wireline log characteristics and subdivision

In most wells the top and base of the Goldwyer Formation have characteristic wireline log signatures, best seen on gamma-ray and sonic logs, which allow for consistent placement of formation boundaries, after consideration of biostratigraphic constraints. The Willara Formation–Goldwyer Formation transition is marked by a distinct inflection in the gamma-ray log from mostly low readings in the upper Willara Formation to a higher, more variable, 'jagged' response in the basal Goldwyer Formation. This reflects a rapid gradation from either carbonate or calcareous mudstone and locally sandstone below the boundary, to mudstone with or without limestone interbeds, above. The inflection ranges from very sharp to more gradational over 10–20 m, but in each case the boundary has been placed at the steepest part of the inflection. The sonic response is similar, although often more subdued. In many wells a sharp gamma-ray spike, often accompanied by a weaker spike on the sonic log, lies 5–37 m below the boundary. In the fully cored well Solanum 1, the spike coincides with an 8 cm-thick distinctive light green clay-rich bed at 602.18 m, interpreted as a tuff. A similar although thinner bed is present at 577.5 m in the same well, but is too thin to produce a significant gamma-ray response above the noisy background. If the prominent spike is a unique tuff, the implication based on stratigraphic position is that the Willara–Goldwyer Formation boundary becomes slightly younger to the west (37 m below the boundary in Solanum 1, and 5 m below the boundary in Hedonia 1: Plates 1–4), assuming that sedimentation rates in the respective areas do not differ by an order of magnitude. Alternatively, several different tuff beds may be involved, as three thin (too thin to identify on gamma-ray logs) probable tuffaceous beds were identified in the lower Goldwyer Formation in DD87SS7.

The upper Goldwyer and overlying Nita Formations are both characterized by sinusoidal oscillations on gamma-ray and sonic logs, but across the boundary there is a distinct inflection in average values (the Nita Formation has a lower average gamma-ray response) and an upward decrease in cycle amplitude. The boundary is placed just below a prominent carbonate bed several metres thick, which commonly gives a low 'U-shaped' gamma-ray response, and can be confidently recognized in most wells as far east as the Barbwire Terrace (Plates 1–4).


0 cm
a)
4
8
12
16
4
8
12
Solanum 1
602.18 m
core tray 99
up
b)
5 mm
c)
1 cm
d)
0 cm
2
4
6
e)
0 cm
2
4
6
f)
0 cm
4
8
12
16

There have been several attempts to subdivide the Goldwyer Formation. Some well completion reports, particularly in the western Broome Platform, have recognized 'lower shale', 'middle limestone', and 'upper shale' members. The 'middle limestone' is also present in the Willara Sub-basin, but poorly developed and subtle on wireline logs. In the Barbwire Terrace area, detailed studies by Western Mining Corporation (WMC) led to the recognition of four informal members (here referred to as WMC units 1 to 4 in ascending order) based on wireline logs and sedimentary facies in fully cored holes (Foster et al., 1986; Georgi, 1986; Winchester-Seeto et al., 2000). During this study, it was found that the WMC subdivision scheme from the Barbwire Terrace could also be applied to the Mowla Terrace and the eastern Broome Platform (Plates 2–4). From regional correlation of wireline signatures, it appears that WMC units 1 and 2 are essentially equivalent to the 'lower shale', unit 3 to the 'middle limestone', and unit 4 to the 'upper shale' member.

Depositional environment

The abundant and diverse macrofossil fauna of the Goldwyer Formation is indicative of open marine shelf conditions. Individual facies imply alternating water depths from quiet subtidal shelf or lagoon conditions (laminated mudstone), to successively higher energy shoal and intertidal conditions (wackestone, packstone, and grainstone). Overall, the formation exhibits two broad deepening and shallowing trends, on which higher frequency (metres to tens of metres) cyclicity is superimposed and most clearly expressed in the wireline log signature. These cycles show characteristics typical of the shallowing-upward carbonate sequences widely reported from peritidal carbonate successions (James, 1984). Where fully developed in platformal areas, each cycle shows an upward shift from relatively quiet (below wave base) subtidal conditions, through zones of increasing energy and decreasing water depth indicated by the presence of wackestone, packstone, and grainstone. Ooidal and oncoidal grainstone at cycle tops in WMC unit 3 demonstrate that shallow and continually agitated deposition marked the top of the first major shallowing trend. This level correlates with the 'middle limestone' in western areas. The second major shallowing trend culminated with exposure and supratidal conditions in the upper Nita Formation. The driving mechanism behind the smaller scale shallowing-upward cycles is uncertain. It could be related to small-scale glacio-eustatic sea level changes, tectonically driven changes in subsidence rates, or autocyclic processes. Whatever process is responsible must operate on a basin-wide scale, as some cycles can be confidently correlated for tens and even hundreds of kilometres. After a detailed discussion of possible mechanisms, McCracken (1997) favoured glacio-eustatic control, but conceded the possibility of local tectonic control of some cycles in the Admiral Bay Fault Zone area.

Figure 4. Drillcore photographs of the Goldwyer and upper Willara Formations: a) pale-green clay bed of probable tuffaceous origin in upper Willara Formation (Solanum 1, base of bed at 602.18 m); b) small complete trilobite in dark-grey shales of the Goldwyer Formation (Solanum 1, 504.6 m); c) partial trilobite, probably *Ptychopyge canningensis*, in grey shales of the Goldwyer Formation (Solanum 1, 498.15 m); d) oncoidal packstone in the central Goldwyer Formation (Santalum 1A, 537 m); e) bioturbated wackestone with dolomitized burrow fillings, Goldwyer Formation (Santalum 1A, 448.6 m); f) typical Goldwyer Formation displaying alternation between grey calcareous mudstone (right), calcareous mudstone with isolated micritic limestone nodules and interbeds (left), and stylonodular wackestone in centre (Kunzea 1, approximately 385 m); all scales in centimetres unless otherwise noted

The massive carbonate build-ups along the Admiral Bay Fault Zone are interpreted as microbial bioherms localized along active fault scarps (McCracken, 1994, 1997; McCracken et al., 1996). Bioherm tops remained in the surf zone throughout deposition of most of the Goldwyer Formation, while the adjacent basin underwent relatively deep-water sedimentation mostly below wave base. Lenticular grainstone and packstone beds, within the shale-rich successions adjacent to the bioherm, comprise material shed off the reef during storm events.

Foster et al. (1999) and Winchester-Seeto et al. (2000) found that the relative abundances of large organic-walled microfossils exhibit a distinct environmental response within the upper Goldwyer and lower Nita Formations. The studies were undertaken in fully cored wells on the Barbwire Terrace, so trends can be related directly to depositional environments inferred from facies and wireline log analysis. Chitinozoans decrease in abundance and diversity with decreasing water depth, and the dominant species changes depending on transgressive or regressive conditions. Scolecodonts were shown to increase in abundance during transgressions. Such studies might be particularly valuable in wells where only limited samples, such as sidewall cores, are available.

Hydrocarbon significance

High concentrations of *Gloeocapsomorpha prisca* (known as kukersite) are preserved locally within the upper Goldwyer Formation (WMC unit 4), with lesser abundance in lower parts of the formation (Foster et al., 1986). The upper Goldwyer Formation source-rock unit is apparently restricted to the Mowla and the western Barbwire Terraces, the latter area being oil prone (Edwards et al., 1997). Lower Goldwyer Formation source rocks were intersected in the same areas, but also extend across the northern Broome Platform (Edwards et al., 1997). It is possible that source-rock horizons extend into the adjacent Fitzroy Trough and Gregory Sub-basin, but the formation has not been intersected by wells in these areas. Nevertheless, according to Edwards et al. (1997), most analysed oils recovered from the Ordovician section (with the exception of those along the Admiral Bay Fault Zone) exhibit a clear biomarker signature characteristic of *G. prisca*. This implies that the Goldwyer Formation contains the main source rocks in the Ordovician section. It should be noted that there is an apparent correlation between high TOC values, good source rocks, and the availability of drillcore. As such, the distribution of potential source rocks may be at least partly influenced by sampling biases.

Where intersected by exploration wells, source-rock intervals of the Goldwyer Formation are commonly immature for hydrocarbon generation, based on conodont alteration indices (Nicoll and Gorter, 1984; Nicoll, 1993). Because of this, conceptual hydrocarbon plays generally require medium-range migration from mature source-rock intervals that are assumed to be present in deep sub-basins, such as the Fitzroy Trough, to reservoirs on adjacent platforms and terraces.

Carbonate beds in the Goldwyer Formation are generally tight and the unit has thus not been considered to have potential as a hydrocarbon reservoir. Late diagenetic dolomitization has locally produced visual vuggy porosity, but adequate permeabilities have not been reported. Intersections of the formation in southeastern parts of the basin (e.g. Wilson Cliffs 1) contain significant fine-grained sandstone, with proportions likely to increase towards the basin margin. The age-equivalent unit in the Amadeus Basin (Stairway Sandstone) has good reservoir potential, so similar facies may be present in the eastern part of the Canning Basin if the Larapintine Seaway concept is valid. Carbonate bioherms along the Admiral Bay Fault Zone contain porous vuggy intervals, and in DD86SS2 oil-soaked core is present over the interval 1570–1580 m in association with base metal mineralization. Any similar carbonate bioherms present elsewhere in the basin may have the potential to contain reservoir beds, if not extensively altered by hydrothermal fluids.

Nita Formation

Definition

The stratotype of the Nita Formation is the interval 1165–1270 m (3821–4165 feet) in Parda 1 (Playford et al., 1975; McTavish and Legg, 1976; Burne et al., 1981), but it has limited core. The lower contact with the Goldwyer Formation is conformable and gradational, and according to Burne et al. (1981) is picked 'at the base of a dominantly dolomite sequence; below this contact the lithology is wholly more than 50% shale'. This definition has not proved fully satisfactory based on results from many of the newer wells. Firstly, the amount of secondary dolomitization and its stratigraphic extent is shown to be highly variable from well to well, and secondly the carbonate-to-shale ratio in the upper Goldwyer Formation is also highly variable from region to region. The latter is particularly evident in some of the fully cored wells. For these reasons, the boundary has been picked in this study at the base of a distinctive cycle on the gamma-ray and sonic logs, with reference to the log of the stratotype. This position can be picked confidently for most wells, with the exception of Blackstone 1 on the Lennard Shelf and wells in the far southeast of the basin. The Nita Formation has an average thickness of about 100 m, and reaches a maximum thickness of 216 m in Crystal Creek 1. Chronostratigraphy is based largely on conodonts, with the Nita Formation restricted to the upper *Phragmodus–Plectodina* Zone of Llanvirn age (Nicoll, 1993; Nicoll et al., 1993; Jones et al., 1998).

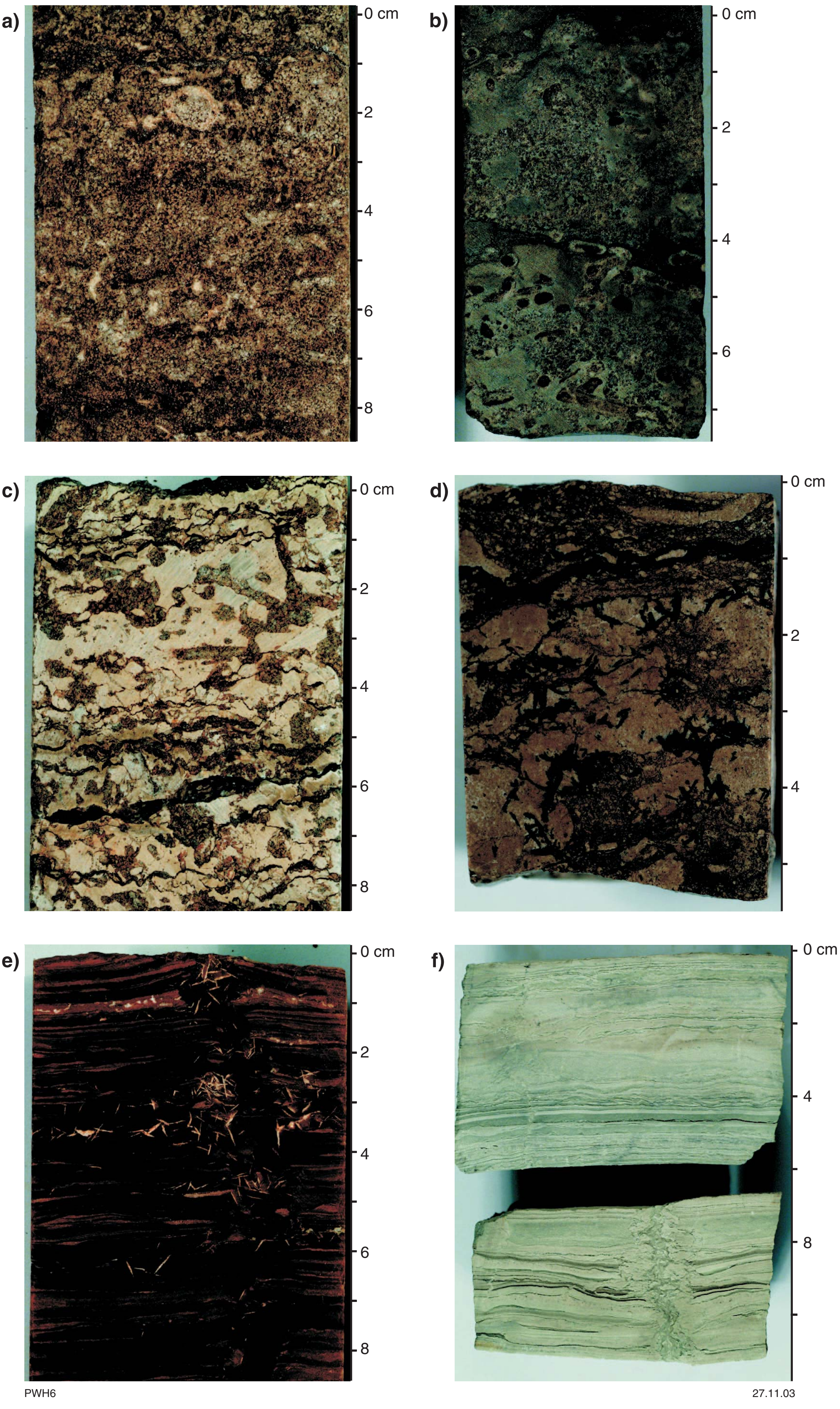
McCracken (1994) formally subdivided the Nita Formation into two members along the Admiral Bay Fault Zone and across the Broome Platform: the Leo Member (27–80 m thick) below, and the Cudalgarra Member (12–21 m thick) above. The contact between the members is locally inferred to be an exposure surface (McCracken, 1997). The stratotype of both is in the fully cored mineral exploration diamond drillhole DD87SS7 (Leo Member: 1482.9 – 1545.5 m; Cudalgarra Member: 1463.3 – 1482.9 m). McCracken (1994) also nominated reference sections with limited core, cuttings, and wireline logs in petroleum exploration holes Leo 1 (Leo Member: 1565–1642 m) and Great Sandy 1 (Cudalgarra Member: 1447–1467 m). The members can be distinguished by their distinctive signature on wireline logs (see below). It seems likely that the supersequence boundary recognized within the Nita Formation mainly from seismic interpretation (Romine et al., 1994; Kennard et al., 1994), corresponds to the Leo–Cudalgarra Member boundary.

Lithofacies

The Nita Formation is dominated by carbonate rocks, both dolostone and limestone, interbedded with lesser amounts of mudstone. Minor fine-grained sandstone was reported in some mud logs, but was not seen in the cores examined. Evaporites or their pseudomorphs may be present near the top of the formation, particularly within the Cudalgarra Member where differentiated.

The relative proportion of dolostone to limestone is highly variable, ranging from 100% dolostone (e.g. Acacia 1, 2, and Percival 1) to greater than 50% limestone elsewhere. Limestone in the lower Nita Formation (Leo Member where differentiated) is generally grey stylonodular wackestone, packstone, and lesser grainstone, similar to that found in the upper Goldwyer Formation. Fragmentary bioclasts and bioturbation are generally abundant low in the formation, but decrease in abundance upwards. Dolostone in the lower to middle part of the Nita Formation is grey to brown and typically coarsely crystalline, and destructive of primary fabrics, suggesting a late diagenetic replacement of original limestone. Vuggy secondary porosity is common (Fig. 5a,b). Where relic

Figure 5. Drillcore photographs of the Nita Formation: a) vuggy porosity in coarsely crystalline diagenetic replacement dolostone (DD87SS7, 1532.1 m); b) vuggy and moldic porosity in dolomitized packstone–grainstone (Santalum 1A, 427 m); c) coarse sucrosic dolostone infilling burrows within stylolitic micritic limestone (DD87SS7, 1525.7 m); d) stylolitic intraclastic dolostone with clusters of lenticular gypsum crystals (Parda 1, core 1, 1186 m); e) laminated dolomitic and calcareous mudstone with small lenticular gypsum crystals, disrupted by a large desiccation crack (DD87SS7, 1480.5 m); f) microbially laminated fine-grained dolostone, with probable desiccation crack in lower part (Parda 1, core 1, 1188 m); all scales in centimetres


a)
0 cm
2
4
6
8
b)
0 cm
2
4
6
c)
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8
d)
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27.11.03

fabrics are preserved, these suggest a precursor similar to the limestone from this part of the formation. Dolomitization may be highly selective, for example involving replacement of burrow infillings by coarse sucrosic dolomite within host limestone (Fig. 5c). Limestone and dolostone units are cyclically interbedded with dolomitic or calcareous mudstone in a fashion similar to that of the upper Goldwyer Formation.

Dolostone of the upper Nita Formation (Cudalgarra Member where differentiated) is commonly fine grained and delicate primary features are often preserved, suggesting a primary to very early diagenetic origin. Bioclasts and bioturbation become rare at this level. Interbedded grey, green, and reddish mudstone increases in abundance towards the top of the formation and is commonly finely laminated or flaser-bedded. Microbial laminations are also common, and subvertical zones of bedding disruption probably caused by desiccation are present (Fig. 5e,f). Evaporites are common, either as primary minerals or pseudomorphs, and include clusters of lenticular gypsum crystals (Fig. 5d,e) and nodular anhydrite. The contact with the Bongabinni Formation is gradational, and is placed at the level where massive red claystone or siltstone becomes dominant.

Wireline log characteristics and subdivision

The Nita Formation has a distinctive wireline log signature, allowing easy recognition and subdivision of the unit in most parts of the basin. The upper Goldwyer and overlying Nita Formations are both characterized by fairly regular facies cyclicity, clearly evident from sinusoidal oscillation of values on the gamma-ray and sonic logs. There is, however, a distinct inflection in average values (the Nita Formation has a lower average gamma-ray response) and an upward decrease in cycle amplitude across the boundary. The boundary is placed just below a prominent carbonate bed several metres thick, which gives a low ‘U-shaped’ gamma-ray response. This can be confidently recognized in most wells as far east as the Barbwire Terrace. The Leo Member is cyclical throughout, but cycle amplitude decreases upward through it. The contact between the Leo and Cudalgarra Members is marked by a sudden upward shift to a higher average gamma-ray response, and less regular cyclicity, a pattern which grades upwards into the irregular high response of the overlying mudstone-dominated Bongabinni Formation. Examination of drillcore indicates that the wireline log cyclicity throughout the Nita Formation is a response to the alternation of mudstone or argillaceous carbonate rocks, with cleaner carbonate units.

Depositional environment

The lower Nita Formation displays classical shallowing-upward carbonate cycles (James, 1984), similar to those observed in the underlying Goldwyer Formation. There is an overall shallowing-upward trend from shallow subtidal to intertidal cycles low in the formation, to upper intertidal to supratidal cycles in the Cudalgarra Member, based on the distribution of primary sedimentary structures, desiccation features, evaporites, and bioturbation. McCracken (1997) has reported evidence of local exposure and karstification at the top of the Leo Member in the Admiral Bay Fault Zone area. As with the Goldwyer Formation, the driving mechanism behind the cyclicity has not been determined with certainty. In some cases the cycles can be correlated over hundreds of kilometres, implying very gentle depositional slopes.

Hydrocarbon significance

Repeated oil and gas shows have led to the Nita Formation being ranked as the most promising potential reservoir unit within the Ordovician section of the Canning Basin. In cores examined during this study, visibly vuggy porosity is commonly present within intervals of late-diagenetic replacement dolostone particularly in the middle to lower Nita Formation, but it is generally not clear to what degree the vugs are interconnected. Karajas and Kernick (1984) reported core-derived porosities of 10 – 18.5% and permeabilities ranging between 35 and 3310 mD in Aquila 1, which penetrated approximately 30 m of water-saturated reservoir beds exhibiting both vuggy and intercrystalline porosity. These reported values are exceptional, and analyses from other wells generally indicate lower porosities and substantially lower permeabilities (Jackson et al., 1994).

Predicting the location of reservoir-quality rocks is likely to be difficult, as the degree of dolomitization varies widely and probably results from complex controls. Norlin (1984) observed that close proximity to faults generally results in more extensive dolomitization, and McCracken (1997) interpreted a complex and multi-phase history for diagenesis of the Nita Formation along the Admiral Bay Fault Zone. In the case of Aquila 1, dolomitization may be in part unconformity-related, as the Nita Formation is unconformably overlain by the Permian Grant Group in this well, a factor unlikely to be conducive to the entrapment of petroleum in the Nita Formation. Primary depositional textures and fabrics are also important. Hillock (1988) found that in the Barbwire Terrace area, reservoir-quality porosity and permeability were restricted to dolomitized, bioturbated mudstone facies, specifically sucrosic dolomite in coarse-grained burrow infills. This facies is present in discrete horizons due to the cyclical nature of the Nita Formation. King (1998a,b) reported the presence of three main types of porosity: intercrystalline, vugular and moldic, and fracture. Of these only intercrystalline porosity is significantly facies-controlled, and mainly restricted to what were inferred to be intertidally deposited carbonate beds in the upper 30 m of the formation. The recognition of an exposure surface with local karstification, including cavern development, at the contact between the Leo and Cudalgarra Members along the Admiral Bay Fault Zone (McCracken, 1997), may have regional implications. This boundary is sharp and clearly detected from wireline logs across the western half of the basin, implying that karst-related reservoirs could be present at this stratigraphic level, particularly along fault-related syn-depositional highs.

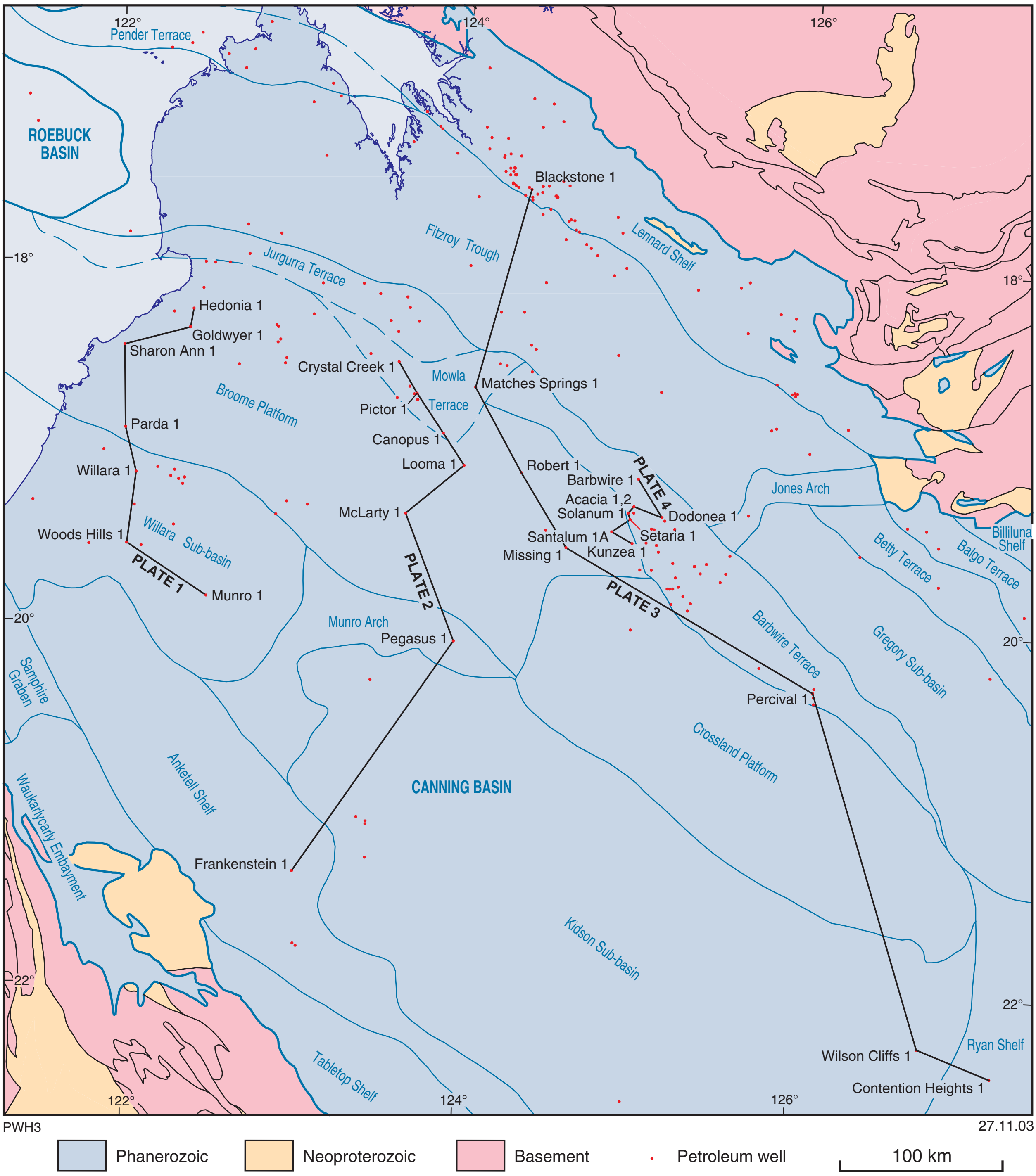


Figure 6. Location diagram for well correlation transects in Plates 1–4

Edwards et al. (1997) stated that most analysed oils extracted from the Nita Formation exhibit a biomarker signature characteristic of the marine alga *Gloeocapsomorpha prisca*. This suggests that they were sourced from the underlying Goldwyer Formation, although Hillock (1988) reported significant quantities of *G. prisca*, as well as other organic material, within the Nita Formation itself. Live oil is also present in the Nita Formation along the Admiral Bay Fault Zone, an area where the Goldwyer Formation is organically lean. The characteristics of this biodegraded oil indicate that it was sourced from organic-rich horizons, referred to as oil shales, that are present in the lower Bongabinni Formation in this area (McCracken, 1994, 1997).

Well correlations

Well correlations of the Nita and Goldwyer Formations and enclosing stratigraphic units are illustrated in Plates 1–4 for 28 selected wells, arranged on four approximately north–south sections across the Canning Basin (Fig. 6).

Previously reported formation tops from well completion reports and subsequent studies were reassessed using wireline logs, lithological data, and available biostratigraphic data. The interval studied in detail extends down from the basal part of the Carribuddy Group, through the Nita and Goldwyer Formations, to at least the upper Willara Formation, provided that the well penetrated to this depth. In many wells the logs are plotted to total depth, thus also including Nambeet Formation and basement intersections in some, but in regions with thick Ordovician successions the lower parts of the well logs were truncated at varying positions below the top of the Willara Formation for practical reasons. Conodont zones and conodont alteration indices from Nicoll (1993) have also been plotted where available.

The WMC unit classification for the Goldwyer Formation is indicated, where possible, as is the 'middle carbonate member' in Plate 1. The Nita Formation has been subdivided into Leo and Cudalgarra Members in Plates 1, 2, and locally in Plate 3. Although it has not been a part of this study, the 'Acacia sandstone member' of the Willara Formation is indicated, where appropriate, based largely on company picks. During the current study, no attempt was made to incorporate sequence stratigraphic schemes inferred by previous authors (Romine et al., 1994; McCracken, 1997), as this would require integration of wireline and seismic data. Supersequence boundary A2–B1 is apparently coincident, or nearly coincident with the Leo–Cudalgarra Member boundary, and the A1–A2 boundary lies in the upper Willara Formation.

In most cases, the formations tops as reassessed during this study (Appendix 3) are close to, or identical to those selected by previous workers. However, in some wells there are significant discrepancies, and the reasons for the reassessments are discussed for each well in Appendix 4.

Conclusions

The Goldwyer and Nita Formations form an overall transgressive–regressive package of mudstone and carbonate, upon which are superimposed smaller-scale shallowing-upward cycles that can be traced, in some cases, over distances of several hundred kilometres using wireline logs. This cyclicity allows high-resolution correlation and subdivision within these formations. Future integration with good-quality seismic data should allow a high-resolution sequence stratigraphic subdivision. Regional distribution trends of shale-dominated or carbonate-dominated facies in the Goldwyer Formation suggest that the currently recognized tectonic subdivisions had some expression in the Ordovician.

Hydrocarbon shows are consistently associated with the Nita Formation, and probably are sourced from *Gloeocapsomorpha prisca*-bearing intervals in the upper Goldwyer Formation, or locally from organic-rich facies in the Bongabinni Formation. Vuggy porosity is widespread in late diagenetic dolostone in the Nita Formation, but permeabilities are commonly low, and predicting the location of good reservoir rocks is difficult.

Source-rock intervals of the Goldwyer Formation, where intersected by exploration wells, are commonly immature for hydrocarbon generation based on conodont alteration indices. As such, conceptual hydrocarbon plays generally require that the source-rock intervals extend into deep sub-basins, such as the Fitzroy Trough, and that generated hydrocarbons can migrate laterally to be trapped within reservoir units on adjacent platforms and terraces.

References

BHP PETROLEUM PTY LTD, 1984, Pictor 1 well completion report: Western Australia Geological Survey, Statutory petroleum exploration report, S2607 A6 (unpublished).

BRADSHAW, M. T., 1993, Australian petroleum systems: PESA Journal, v. 21, p. 43–53.

BROWN, S. A., BOSERIO, I. M., JACKSON, K. S., and SPENCE, K. W., 1984, The geological evolution of the Canning Basin — implications for petroleum exploration, *in* The Canning Basin, W.A. *edited by* P. G. PURCELL: Geological Society of Australia and Petroleum Exploration Society of Australia, Canning Basin Symposium, Perth, W.A., 1984, Proceedings, p. 85–96.

BURNE, R. V., GORTER, J. D., and SAXBY J. D., 1979, Source rocks and hydrocarbon potential of the Canning Basin, Western Australia: BMR Journal of Australian Geology and Geophysics, v. 2, p. 271–288.

BURNE, R. V., GORTER, J. D., and PASSMORE, V. L., (compilers) 1981, Appendices: Stratigraphic units of intervals 1 to 11, *in* Geological evolution of the Canning Basin, Western Australia *by* D. J. FORMAN and D. W. WALES, Australia Bureau of Mineral Resources, Bulletin 210, BMR Microform MF170.

COOK, P. J., and TOTTERDELL, J. M., 1990, The Ordovician palaeogeography of Australia: Australia Bureau of Mineral Resources, Record 1990/41, 81p.

EDWARDS, D. S., McCRACKEN, S. R., MURRAY, A. P., and FOSTER, C. B., 1995, Geochemistry of Ordovician algal-rich sediments and related oils from the Admiral Bay Fault Zone, Canning Basin, *in* Australian Organic Geochemistry Conference *edited by* B. H. MICHAELSEN and D. M. McKIRDY, University of Adelaide, 5–7 July 1995, p. 26–27.

EDWARDS, D. S., SUMMONS, R. E., KENNARD, J. M., NICOLL, R. S., BRADSHAW, J., BRADSHAW, M., FOSTER, C. B., O'BRIEN, G. W., and ZUMBERGE, J. E., 1997, Geochemical characteristics of Palaeozoic petroleum systems in northwestern Australia: APPEA Journal, v. 37, p. 351–377.

ELLIOT, R. M. L., 1961, Appendix 7, New and amended formation names, *in* Thangoo no. 1 and no. 1A wells, Western Australia *compiled by* V. PUDOVSKIS and S. P. WILLMOTT: Australia Bureau of Mineral Resources, Petroleum Search Subsidies Act, Publication 14, 43p.

FORMAN, D. J., and WALES, D. W., 1981, Geological evolution of the Canning Basin, Western Australia: Australia Bureau of Mineral Resources, Bulletin 210, 91p.

FOSTER, C. B., O'BRIEN, G. W., and WATSON, S. T., 1986, Hydrocarbon source potential of the Goldwyer Formation, Barbwire Terrace, Canning Basin, Western Australia: APEA Journal, v. 26, p. 142–155.

FOSTER, C. B., and WILLIAMS, G. E., 1991, Late Ordovician – Early Silurian age for the Mallowa Salt of the Carribuddy Group, Canning Basin, Western Australia, based on occurrences of *Tetrahedraletes medinensis* Strother & Traverse 1979: Australian Journal of Earth Sciences, v. 38, p. 223–228.

FOSTER, C. B., WINCHESTER-SEETO, T., and O'LEARY, T. O., 1999, Preliminary study of the environmental significance of Middle Ordovician (Darriwilian) acid resistant microfossils from the Canning Basin, Australia: Acta Universitatis Carolinae, v. 43, p. 311–314.

GEORGI, H. T., 1986, Lithofacies and depositional environments of the upper Goldwyer Formation, central Canning Basin, Western Australia: University of Adelaide, BSc Hons thesis (unpublished).

HILLOCK, P. M., 1988, The petrophysics of the Nita Formation central Canning Basin, Western Australia: University of Adelaide, BSc Hons thesis (unpublished).

JACKSON, M. J., ZEILINGER, I., KENNARD, J. M., and SOUTHGATE, P. N., 1994, Canning Basin Project (Stage II) — geochemical and porosity/permeability data: Australian Geological Survey Organisation, Record 1994/59, 240p.

JAMES, N. P., 1984, Shallowing-upward sequences in carbonates, *in* Facies Models (2nd edition) *edited by* R. G. WALKER: Geological Association of Canada, p. 213–228.

JONES, P. J., NICOLL, R. S., EDWARDS, D. S., KENNARD, J. M., and GLENN, K. C., 1998, Canning Basin biozonation and stratigraphy, 1998: Australian Geological Survey Organisation, Chart 2.

KARAJAS, J., and KERNICK, C. N., 1984, A prospective Nita Formation reservoir trend on the Broome Platform, *in* The Canning Basin, W.A. *edited by* P. G. PURCELL: Geological Society of Australia and Petroleum Exploration Society of Australia, Canning Basin Symposium, Perth, W.A., 1984, Proceedings, p. 169–177.

KENNARD, J. M., JACKSON, M. J., ROMINE, K. K., SHAW, R. D., and SOUTHGATE, P. N., 1994, Depositional sequences and associated petroleum systems of the Canning Basin, W.A., *in* The Sedimentary Basins of Western Australia *edited by* P. G. PURCELL and R. R. PURCELL: Petroleum Exploration Society of Australia, Western Australian Basins Symposium, Perth, W.A., 1994, Proceedings, p. 657–676.

KING, M. R., 1998a, The Palaeozoic play in the south Canning Basin — results of Looma 1, *in* The Sedimentary Basins of Western Australia 2 *edited by* P. G. PURCELL and R. R. PURCELL: Petroleum Exploration Society of Australia, Western Australian Basins Symposium, Perth, W.A., 1998, Proceedings, p. 695–714.

KING, M. R., 1998b, Looma 1 reopens the Palaeozoic play in south Canning Basin: APPEA Journal, v. 38, part 1, p. 254–277.

LAURIE, J. R., 1997, Early Ordovician fauna of the Gap Creek Formation, Canning Basin, Western Australia: AGSO Journal of Australian Geology and Geophysics, v. 16, p. 701–716.

LEGG, D. P., 1976, Ordovician trilobites and graptolites from the Canning Basin, Western Australia: Geologica et Palaeontologica, v. 10, p. 1–58.

LEGG, D. P., 1978, Ordovician biostratigraphy of the Canning Basin, Western Australia: Alcheringa, v. 2, p. 321–334.

LITTLE, B., 1992, The Ordovician Acacia sands, Western Australia: University of Adelaide, BSc Hons thesis (unpublished).

McCRACKEN, S., 1994, Timing of hydrocarbon migration into the Admiral Bay Fault Zone, Canning Basin, *in* The Sedimentary Basins of Western Australia *edited by* P. G. PURCELL and R. R. PURCELL: Petroleum Exploration Society of Australia, Western Australian Basins Symposium, Perth, W.A., 1994, Proceedings, p. 739–751.

McCRACKEN, S. R., 1997, Stratigraphic, diagenetic, and structural controls of the Admiral Bay carbonate-hosted Zn–Pb–Ag deposit, Canning Basin, Western Australia: University of Western Australia, PhD thesis (unpublished).

McCRACKEN, S. R., ETMINAN, H., CONNOR, A. G., and WILLIAMS, V. A., 1996, Geology of the Admiral Bay carbonate-hosted zinc–lead deposit, Canning Basin, Western Australia, *in* Carbonate-hosted lead–zinc deposits *edited by* D. F. SANGSTER: Society of Economic Geologists, Special Publication no. 4, p. 330–349.

McTAVISH, R. A., and LEGG, D. P., 1972, Middle Ordovician correlation — conodont and graptolite evidence from Western Australia: Neues Jahrbuch für Geologie und Paläeontologie, v. 8, p. 465–474.

McTAVISH, R. A., and LEGG, D. P., 1976, The Ordovician of the Canning Basin, Western Australia, *in* The Ordovician System: Proceeding of a Palaeontological Association symposium, Birmington, September 1974 *edited by* M. G. BASSETT: University of Wales Press and National Museum of Wales, Cardiff, p. 447–478.

NICOLL, R. S., 1984, Conodont studies in the Canning Basin — a review and update, *in* The Canning Basin, W.A. *edited by* P. G. PURCELL: Geological Society of Australia and Petroleum Exploration Society of Australia, Canning Basin Symposium, Perth, W.A., 1984, Proceedings, p. 179–186.

NICOLL, R. S., 1993, Ordovician conodont distribution in selected petroleum exploration wells, Canning Basin, Western Australia: Australian Geological Survey Organisation, Record 1993/17, 136p.

NICOLL, R. S., and GORTER, J. D., 1984, Conodont colour alteration, thermal maturation and the geothermal history of the Canning Basin, Western Australia: APEA Journal, v. 24, p. 234–258.

NICOLL, R. S., LAURIE, J. R., and ROCHE, M. T., 1993, Revised stratigraphy of the Ordovician (Late Tremadoc–Arenig) Prices Creek Group and Devonian Poulton Formation, Lennard Shelf, Canning Basin, Western Australia: AGSO Journal of Australian Geology and Geophysics, v. 14, p. 65–76.

NICOLL, R. S., OWEN, M., SHERGOLD, J. H., LAURIE, J. R., and GORTER, J. D., 1988, Ordovician event stratigraphy and the development of a Larapintine Seaway, central Australia: Bureau of Mineral Resources, Australia, Record 1988/42, p. 72–77.

NICOLL, R. S., ROMINE, K. K., and WATSON, S. T., 1994, Early Silurian (Llandovery) conodonts from the Barbwire Terrace, Canning Basin, Western Australia: AGSO Journal of Australian Geology and Geophysics, v. 15, p. 247–255.

NORLIN, W. K., 1984, Hydrocarbon potential in the Great Sandy region, W.A., *in* The Canning Basin, W.A. *edited by* P. G. PURCELL: Geological Society of Australia and Petroleum Exploration Society of Australia, Canning Basin Symposium, Perth, W.A., 1984, Proceedings, p. 179–186.

PLAYFORD, P. E., COPE, R. N., COCKBAIN, A. E., LOW, G. H., and LOWRY, D. C., 1975, Phanerozoic, *in* The Geology of Western Australia: Western Australia Geological Survey, Memoir 2, p. 223–433.

PURCELL, P. G., and POLL, J., 1984, The seismic definition of the main structural elements of the Canning Basin, *in* The Canning Basin, W.A. *edited by* P. G. PURCELL: Geological Society of Australia and Petroleum Exploration Society of Australia, Canning Basin Symposium, Perth, W.A., 1984, Proceedings, p. 74–84.

ROMINE, K. K., SOUTHGATE, P. N., KENNARD, J. M., and JACKSON, M. J., 1994, The Ordovician to Silurian phase of the Canning Basin W.A., *in* The Sedimentary Basins of Western Australia *edited by* P. G. PURCELL and R. R. PURCELL: Petroleum Exploration Society of Australia, Western Australian Basins Symposium, Perth, W.A., 1994, Proceedings, p. 677–696.

RUSSELL, T., and EDWARDS, H., 1984, Cudalgarra 1 well completion report: Western Australia Geological Survey, Statutory petroleum exploration report, S2648 A2 (unpublished).

SHAW, R. D., SEXTON, M., and ZEILINGER, I., 1994, The tectonic framework of the Canning Basin, W.A., including 1:2 million structural elements map of the Canning Basin: Australian Geological Survey Organisation, Record 1994/48, 89p.

SKWARKO, S. K., 1967, Some Ordovician graptolites from the Canning Basin, Western Australia: 1. On the structure of *Didymograptus artus* Elles & Wood: Bureau of Mineral Resources, Australia, Bulletin 92, p. 171–189.

SKWARKO, S. K., 1974, Some Ordovician graptolites from the Canning Basin, Western Australia. 2. Graptolites from the Goldwyer No. 1 well: Australia Bureau of Mineral Resources, Bulletin 150, p. 43–65.

TAYLOR, D., 1992, A review of Ordovician source rocks, Canning Basin, Western Australia: Australia Bureau of Mineral Resources, Record 1992/43, 87p.

TOWNER, R. R., and GIBSON, D. L., 1983, Geology of the onshore Canning Basin, Western Australia: Australia BMR, Bulletin 215, 51p.

TYLER, I. M., and HOCKING, R. M., 2001, Tectonic units of Western Australia (scale 1:2 500 000): Western Australia Geological Survey.

WATSON, S. T., 1988, Ordovician conodonts from the Canning Basin (W. Australia): Palaeontographica Abt. A, v. 203, p. 91–147.

WINCHESTER-SEETO, T., FOSTER, C., and O'LEARY, T. O., 2000, The environmental response of Middle Ordovician large organic walled microfossils from the Goldwyer and Nita Formations, Canning Basin, Western Australia: Review of Palaeobotany and Palynology, v. 113, p. 197–212.

Appendix 1

Petroleum exploration and stratigraphic wells intersecting the Nita and Goldwyer Formations

Petroleum well name	*S number*	*Latitude (south)*	*Longitude (east)*	*Total depth (m)*	*Intersects Nita Formation*	*Intersects Goldwyer Formation*	*Petroleum shows in Nita and Goldwyer Formations*[a]	*Other shows in Ordovician–Silurian section*[a]
Acacia 1	S1849	19°19'44.95"	124°59'43.66"	1 209	X	X	Nita: minor oil bleeding from cores, common fluorescence; Goldwyer: minor oil bleeding from cores, common fluorescence	Willara: fluorescence
Acacia 2	S2161	19°19'46.95"	124°59'43.66"	1 575	X	X	Nita: minor fluorescence, trace gas; Goldwyer: common fluorescence, trace gas	Willara: fluorescence, trace bitumen, trace gas; Nambeet: fluorescence, trace gas
Anna Plains 1	S3233	19°20'13.53"	121°28'04.83"	1 161	X	x	–	–
Antares 1	S3238	18°43'57.59"	123°41'42.61"	1 291	X	x	Nita: minor fluorescence	
Aquila 1	S2240	18°34'53.02"	122°40'13.69"	1 735	X	X	Nita: trace hydrocarbons	
Barbwire 1	S732	19°10'33.32"	125°01'04.01"	1 070	X	X	–	–
Blackstone 1	S379	17°35'07.92"	124°21'10.98"	3 050	X	x	–	–
Calamia 1	S3245	19°34'44.40"	121°47'51.80"	1 671	X	X	Nita: gas show	
Canopus 1	S2166	18°56'47.98"	123°52'05.88"	1 779	X	X	Nita: fluorescence, minor gas show, trace oil in drilling fluid; Goldwyer: fluorescence, minor gas show	Carribuddy, Willara: minor gas shows
Carina 1	S2164	19°21'12.18"	123°04'48.77"	1 603	X	x	–	–
Contention Heights 1	S874	22°25'30.93"	127°13'35.72"	1 791	X	X	–	–
Crystal Creek 1	S3363	18°33'22.26"	123°36'07.99"	2 504	X	X	Nita: traces of oil in cuttings, oil bled from core, common fluorescence, minor gas show; Goldwyer: bituminous oil stains, minor fluorescence, minor gas shows	Willara: bituminous dead oil stains, minor gas shows
Cudalgarra 1	S2648	19°13'13.15"	122°19'20.25"	1 703	X	x	Nita: minor oil bled from vugs in core, minor gas shows, fluorescence and oil stain throughout, minor oil from DST (39º API); Goldwyer: fluorescence, minor gas shows in altered reef complex	Carribuddy: fluorescence and minor gas shows in lower part
Cudalgarra 2	S2852	19°12'15.02"	122°16'33.95"	1 550	X	x	Nita: minor hydrocarbon shows	Carribuddy: minor hydrocarbon shows
Dampier Downs 1	S90	18°17'56.11"	123°06'09.31"	923	x	nr	–	–
Darriwell 1	S3337	19°35'18.54"	122°06'19.14"	1 600	X	x	–	–
Dodonea 1	S2864	19°23'06.15"	125°09'43.35"	2 215	rm	X	Goldwyer: DST produced 10 l of 18.5° API oil and 60 m of oil-cut mud	Nambeet: 85 m^3/day gas from DST
Dodonea 2	S3149	19°24'12.95"	125°10'45.66"	1 688	X	x	Nita: trace of oil	–
Edgar Range 1	S435	18°45'19.94"	123°35'43.23"	1 968	X	X	Goldwyer: pinpoint fluorescence	Carribuddy: oil bled from core, strong fluorescence
Frankenstein 1	S3417	21°22'50.57"	123°01'01.64"	2 803	X	X	–	–
Fruitcake 1	S20753	19°28'19.97"	124°28'51.77"	1 696	X	X	Nita: trace gas; Goldwyer: trace gas	Willara: trace gas
Goldwyer 1	S91	18°22'46.10"	122°23'03.61"	1 439	rm	X	Goldwyer: traces of oil in cores and cuttings, fluorescence	Willara: traces of oil
Great Sandy 1	S1911	19°12'42.73"	122°21'22.02"	1 771	X	X	Nita: ~0.5 l oil from DST (25.2º API); minor gas shows, fluorescence	Carribuddy: fluorescence
Great Sandy 2	S20013	19°12'42.73"	122°21'21.83"	1 576	X	x	–	Carribuddy: shows in lower part
Hedonia 1	S2599	18°16'31.02"	122°24'09.69"	1 543	rm	X	–	–
Hilltop 1	S3177	18°17'31.92"	122°17'24.13"	1 770	rm	X	–	–
Juno 1	S2872	19°21'49.83"	122°03'47.81"	1 750	x	nr	–	–
Kanak 1	S20232	18°22'36.32"	122°23'02.39"	1 365	rm	X	–	Willara: minor oil from DST
Kidson 1	S244	22°36'59.52"	125°00'34.93"	4 431	?	X	–	–
Kunzea 1	S2604	19°32'01.35"	124°59'27.56"	450	X	x	Nita: local fluorescence; Goldwyer: local fluorescence	–
Leo 1	S3368	19°14'50.17"	122°20'44.31"	2 411	X	X	Nita: good hydrocarbon shows	Carribuddy, Willara: hydrocarbon shows

Appendix 1 (continued)

Petroleum well name	*S number*	*Latitude (south)*	*Longitude (east)*	*Total depth (m)*	*Intersects Nita Formation*	*Intersects Goldwyer Formation*	*Petroleum shows in Nita and Goldwyer Formations*[(a)]	*Other shows in Ordovician–Silurian section*[(a)]
Looma 1	S20328	19°07'24.86"	123°59'39.42"	2 535	X	X	Nita: oil bled from vugs in cores, scattered fluorescence	Willara (‘Acacia sandstone member’): oil bled from vugs in core; Nambeet: gas shows
Lovell’s Pocket 1	S20014	18°30'52.14"	123°26'13.98"	1 924	X	X	Nita: oil staining, fluorescence, trace gas; Goldwyer: oil staining, fluorescence, trace gas	Willara: trace bitumen, fluorescence, trace gas
Matches Springs 1	S500	18°41'21.11"	124°03'06.81"	2 835	X	x	–	–
McLarty 1	S415	19°23'38.87"	123°39'24.40"	2 591	X	X	–	–
Missing 1	S20729	19°33'57.97"	124°36'10.67"	1 810	X	X	Goldwyer: trace gas	–
Munro 1	S698	19°51'50.15"	122°29'23.26"	2 116	X	X	–	–
Musca 1	S2168	19°20'14.33"	122°57'24.97"	1 535	X	x	Nita: trace of fluorescence and oil	Carribuddy: trace of oil
Nita Downs 1	S2452	19°09'15.13"	122°11'59.57"	1 849	X	x	Nita: good hydrocarbon shows; Goldwyer: hydrocarbon shows	Carribuddy: hydrocarbon shows
Parda 1	S198	18°56'02.24"	122°00'33.01"	1 909	X	X	–	–
Pegasus 1	S3338	20°05'45.60"	123°57'8.83"	2 995	X	X	–	–
Percival 1	S2819	20°19'50.64"	126°00'59.97"	2 448	X	X	Nita: minor gas show; Goldwyer: good gas show and fluorescence	Willara, Nambeet: trace gas
Pictor 1	S2607	18°45'46.83"	123°42'57.68"	2 146	X	X	Nita: production test delivered 6.2×10^4 m^3/day (2.2 MMcf/day) gas, 3.8 kL/day (24 bbl/day) oil (45° API)	Carribuddy, Willara: gas shows
Pictor 2	S20049	18°45'52.15"	123°42'52.07"	1 065	X	x	Nita: production test, 7.2×10^3 m^3/day (0.261 MMcf/day) gas, 1.7 kL/day (10.5 bbl/day) oil/condensate	–
Robert 1	S20728	19°09'21.96"	124°19'47.67"	1 826	X	x	–	–
Robert 1 Sidetrack 1	S20728	19°09'21.96"	124°19'47.67"	1 628		x	–	–
Roebuck Bay 1	S102	18°09'33.05"	122°27'33.33"	1 222	X	?	–	–
Santalum 1A	S2426	19°28'18.12"	124°52'10.67"	629	X	x	Nita: minor fluorescence; Goldwyer: minor fluorescence and oil staining	–
Setaria 1	S3433	19°24'2.95"	124°58'32.66"	956	rm	X	Goldwyer: trace of hydrocarbons in cuttings	Willara (‘Acacia sandstone member’): hydrocarbon shows
Sharon Ann 1	S20231	18°28'34.62"	122°00'6.49"	1 830	X	X	–	–
Solanum 1	S2408	19°21'53.95"	124°57'46.66"	834	X	X	Nita: fluorescence and trace oil staining; Goldwyer: minor fluorescence	–
Sunshine 1	S20110	18°27'26.04"	122°53'41.08"	736	rm	x	–	–
Tappers Inlet 1	S641	16°51'32.79"	122°35'26.79"	2 856	rm	X	–	–
Thangoo 1/1A	S91	18°21'43.88"	122°53'11.94"	1 655	rm	X	Goldwyer: oil stain, oil bleeding from cores, fluorescence, trace gas	Willara: minor oil staining and fluorescence
Thangoo 2	S852	18°26'27.27"	122°54'37.21"	1 472	rm	X	–	–
Twin Buttes 1	S3135	18°32'37.01"	122°56'46.68"	1 600	X	X	–	–
Vela 1	S2170	19°24'37.71"	122°53'40.79"	1 909	X	x	–	–
West Blackstone 1	S2801	17°34'26.61"	124°20'16.89"	1 943	rm	x	–	–
Willara 1	S214	19°10'53.60"	122°04'21.80"	3 903	X	X	–	–
Wilson Cliffs 1	S419	22°16'33.94"	126°46'59.72"	3 503	X	X	–	–
Woods Hills 1	S2710	19°34'28.94"	122°01'13.31"	1 978	X	X	Goldwyer: minor gas show	Willara: minor gas show

NOTES: Underlined wells used in Plates 1–4 and detailed in Appendix 3, 5
Depths in metres below KB
Location coordinates converted to Geocentric Datum of Australia (GDA94)

nr not reached
rm removed by erosion
X fully intersected

x partial intersection
(a) summarized from well completion reports

Appendix 2

Selected mineral exploration drillholes intersecting the Nita and Goldwyer Formations

Mineral exploration drillholes	*I number*	*A number*	*Latitude (south)*	*Longitude (east)*	*Total depth (m)*	*Intersects Nita Formation*	*Intersects Goldwyer Formation*	*Petroleum shows in Nita and Goldwyer Formations*[(a)]	*Other shows in Ordovician–Silurian section*[(a)]
DD86SS2 (CRAE)	I7215	A22015	19°13'14.53"	122°19'24.00"	1 754	X	X	Nita: oil staining; Goldwyer: oil staining and oil bleeding from cores	–
DD86SS3 (CRAE)	I7215	A22015	19°12'33.83"	122°17'13.00"	1 724	X	x	Nita: oil in vugs; Goldwyer: trace bituminous material, oil in vugs	–
DD88SS4 (CRAE)	I7215	A22015	19°21'43.02"	122°27'18.70"	1 448	X	x	Nita: oil in vugs, stains, oil seeping from cores	–
DD87SS6 (CRAE)	I7215	A26351	19°10'00.43"	122°13'03.00"	1 613	X	x	Nita/Goldwyer: staining, oil in vugs, bituminous material	–
DD87SS7 (CRAE)	I7215	A26351	19°12'56.03"	122°19'25.70"	1 819	X	X	–	–
DD88SS8 (CRAE)	I7215	A26351	19°11'21.03"	122°15'23.70"	1 853	X	x	Nita: oil bleeding from fractures; Goldwyer: oil staining	–
DD88SS9 (CRAE)	I7215	A26351	19°11'21.03"	122°15'21.70"	1 753	X	x	Nita: minor oil shows	–
DD88SS10 (CRAE)	I7215	A26351	19°15'53.01"	122°36'57.70"	1 647	X	x	Nita: oil staining	–
DD88SS11 (CRAE)	I7215	A26351	19°18'45.01"	122°44'25.70"	1 825	x	nr	–	–
DD88SS12 (CRAE)	I7215	A28951	19°24'18.99"	122°53'56.69"	1 869	X	x	Nita/Goldwyer: minor hydrocarbon shows	–
DD88SS13 (CRAE)	I7215	A28951	19°07'35.03"	122°10'16.70"	1 527	X	x	Nita/Goldwyer: oil bleeding out of vugs	–
DD89SS14 (CRAE)	I7215	A28951	19°13'20.03"	122°16'32.70"	1 620	X	x	Nita: oil bleeding from vugs; Goldwyer: oil stains and bleeding from vugs	– –
DD89SS15 (CRAE)	I7215	A28951	19°13'09.03"	122°19'05.70"	1 638	X	x	Nita: hydrocarbon show at top; Goldwyer: trace hydrocarbons associated with veins	–
DD89SS16 (CRAE)	I7215	A28951	19°13'18.03"	122°19'45.70"	1 508	X	x	Nita/Goldwyer: hydrocarbon staining and bleeding from cores	–
DD89SS17 (CRAE)	I7215	A28951	19°13'07.03"	122°20'14.70"	1 519	X	x	Nita/Goldwyer: hydrocarbon staining and bleeding from cores	–
DD89SS18 (CRAE)	I7215	A28951	19°09'39.03"	122°13'18.70"	1 536	X	x	–	–
DD89SS19 (CRAE)	I7215	A31831	19°09'30.03"	122°11'49.70"	1 686	X	x	–	–
DD90SS20 (CRAE)	I7215	A31831	19°09'53.03"	122°13'07.70"	1 506	X	x	–	Carribuddy: bitumen and oil bleeding from cores
DD90SS21 (CRAE)	I7215	A31831	19°10'04.03"	122°12'59.70"	1 657	X	x	–	–
DD91SS22 (CRAE)	I5846	A34538	18°58'24.03"	121°52'51.70"	1 433	X	x	–	–
DD90SS23 (CRAE)	I5846	A34538	19°02'22.03"	122°04'31.70"	1 394	X	x	–	–
DD91SS24 (CRAE)	I5846	A34538	19°01'49.02"	121°59'25.70"	1 463	X	x	–	–
BW1 (Pasminco)	I9423	A38033	19°25'16.95"	124°59'38.66"	468	X	x	Nita: minor biodegraded oil	–
BW3A (Pasminco)	I9423	A38033	19°32'57.95"	125°01'12.66"	362	X	?	–	–
BW5 (Pasminco)	I9423	A38033	19°36'37.95"	125°02'37.67"	678	X	x	Nita: minor oil staining	–
BW21 (Pasminco)	I9423	A40680	19°14'07.95"	124°53'57.66"	465	?	?x	–	–
BW26 (Pasminco)	I9423	A49925	19°08'56.64"	124°47'59.08"	468	x	nr	–	Carribuddy: minor bitumen

NOTES: Underlined wells detailed in Appendix 3, 5
Depths in metres below KB
Location coordinates converted to Geocentric Datum of Australia (GDA94)

nr not reached
rm removed by erosion
X fully intersected

x partial intersection
(a) summarized from well completion reports

Appendix 3

Formation tops and thickness data for selected wells

Well name	*Latitude (south)*	*Longitude (east)*	*Total depth (m)*	*Top Nita Fm (m)*	*Top Leo Mbr (m)*	*Top Goldwyer Fm (m)*	*Base Goldwyer Fm (m)*	*Thickness Nita Fm (m)*	*Thickness Cudalgarra Mbr (m)*	*Thickness Leo Mbr (m)*	*Thickness Goldwyer Fm (m)*
Acacia 2	19°19'46.95"	124°59'43.66"	1 575	695	nd	757	1 042	62	nd	nd	285
Barbwire 1	19°10'33.32"	125°01'04.01"	1 070	*753	nd	784	1 060	31	nd	nd	276
Blackstone 1	17°35'07.92"	124°21'10.98"	3 050	*2 220	nd	~2 311	nr	~91	nd	nd	>~739
Canopus 1	18°56'47.98"	123°52'05.88"	1 779	1 092	1 118	1 224	1 750	132	26	106	526
Contention Heights 1	22°25'30.93"	127°13'35.72"	1 791	~1 388	nd	~1 411	~1 495	~23	nd	nd	~84
Crystal Creek 1	18°33'22.26"	123°36'07.99"	2 504	1 573	~1 618	1 789	2 250	216	~45	~171	461
Dodonea 1	19°23'06.15"	125°09'43.35"	2 215	rm	rm	*1 426	1 746	rm	rm	rm	320
Frankenstein 1	21°22'50.57"	123°01'01.64"	2 803	2 200	2 229	2 266	2 384	66	29	37	118
Goldwyer 1	18°22'46.10"	122°23'03.61"	1 439	rm	rm	*849	1 076	rm	rm	rm	227
Hedonia 1	18°16'31.02"	122°24'09.69"	1 543	rm	rm	*916	1 050	rm	rm	rm	134
Kunzea 1	19°32'01.35"	124°59'27.56"	450	292	nd	350	nr	58	nd	nd	>100
Looma 1	19°07'24.86"	123°59'39.42"	2 535	1 225	1 261	1 373	1 934	148	36	112	561
Matches Springs 1	18°41'21.11"	124°03'06.81"	2 835	2 019	~2 080	2 208	nr	189	~61	~128	>627
McLarty 1	19°23'38.87"	123°39'24.40"	2 591	1 577	1 631	1 688	2 060	111	54	57	372
Missing 1	19°33'57.97"	124°36'10.67"	1 810	980	1 000	1 053	1 440	73	20	53	387
Munro 1	19°51'50.15"	122°29'23.26"	2 116	1 500	1 520	1 584	~1 800	84	20	64	216
Parda 1	18°56'02.24"	122°00'33.01"	1 909	1 165	1 184	1 267	1 493	102	19	83	226
Pegasus 1	20°05'45.60"	123°57'08.83"	2 995	2 245	2 289	2 345	2 632	100	44	56	287
Percival 1	20°19'50.64"	126°04'59.97"	2 448	2 013	nd	2 033	2 186	20	nd	nd	153
Pictor 1	18°45'46.83"	123°42'57.68"	2 146	879	918	1 041	1 514	162	39	123	473
Robert 1	19°09'21.96"	124°19'47.67"	1 826	1 099	1 147	1 232	nr	133	48	85	>594
Santalum 1A	19°28'18.12"	124°52'10.67"	629	387	nd	452	nr	65	nd	nd	>177
Setaria 1	19°24'02.95"	124°58'32.66"	956	rm	rm	*145	388	rm	rm	rm	243
Sharon Ann 1	18°28'34.62"	122°00'06.49"	1 830	*890	*890	942	1 361	52	rm	52	419
Solanum 1	19°21'53.95"	124°57'46.66"	834	223	nd	283	563	60	nd	nd	280
Willara 1	19°10'53.60"	122°04'21.80"	3 903	1 743	1 760	1 874	2 610	131	17	114	736
Wilson Cliffs 1	22°16'33.94"	126°46'59.72"	3 503	~1 632	nd	~1 662	2 847	~30	nd	nd	~1 185
Woods Hills 1	19°34'28.94"	122°01'13.31"	1 978	1 325	1 343	1 420	1 831	95	18	77	411
DD86SS2	19°13'14.53"	122°19'24.00"	1 754	~1 239	1 343	1 369	nr	~50	~24	26	>385
DD87SS7	19°12'56.03"	122°19'25.70"	1 819	1 463	1 483	1 546	1 780	83	20	63	234

NOTES: Depths in metres below KB

Fm: Formation
Mbr: Member
nd: not determined
nr: not reached
rm: removed by erosion
* erosional contact
> incomplete intersection
~ approximate

Appendix 4

Explanatory notes for well correlation Plates 1–4

Plates 1–4 illustrate well correlations of the Nita and Goldwyer Formations and enclosing stratigraphic units in 28 selected wells arranged on four approximately north–south transects across the Canning Basin. In some cases reassessed formation tops (see Appendix 3 for formation tops used in this report) differ significantly from those used by previous authors. The reasons for such discrepancies are discussed below.

Frankenstein 1: This well was drilled to basement on the Anketell Shelf southwest of the Kidson Sub-basin, and is the only well to intersect pre-Carribuddy Group Ordovician units in this area. Command Petroleum NL (1989) considered that the pre-Carribuddy Group succession in this well comprised only the Nita and Goldwyer Formations, with the lower of these units unconformable on Precambrian basement, and that the Willara and Nambeet Formations were absent. This interpretation was supported by palynology from sidewall cores (Purcell, 1989). If correct, it requires the presence of a significant sandstone unit within the Goldwyer Formation (2385–2433 m), not recognized elsewhere. However, the wireline log signature of the sandstone unit and underlying strata is similar to that of the Willara and Nambeet Formations in the nearest wells. In addition, conodonts from cuttings in the interval 2537–2543 m are indicative of the *Jumudontus gananda* Zone (normally found in the Willara Formation), and those from 2645 to 2675 m are from the *Prioniodus elegans–Bergstroemognathus extensus* Zone (normally found in the Nambeet Formation; Nicoll, 1993). Further biostratigraphic studies may be required to reconcile the palynological and conodont data, but it is here tentatively considered that this well intersected relatively thin Goldwyer Formation (~2266–2384 m) overlying the Willara and Nambeet Formations (2384–2666 m). The Willara Formation thus picked has a sandstone-rich upper part, perhaps equivalent to the ‘Acacia sandstone member’. The position of the Willara–Nambeet Formation contact is difficult to place accurately, other than that it should lie between 2543 m and 2645 m as required by the conodont data.

Matches Springs 1: This well has been cited as the thickest known intersection of the Nita Formation (250 m; Burne et al., 1981; Towner and Gibson, 1983). However, a comparison with the wireline log signature of other wells in the region, and also with the stratotype (Parda 1) indicates that the base should be placed at 2208 m (rather than 2277 m), leaving a thickness of 189 m, similar to that in nearby wells. The thickest intersection of the Nita Formation is thus 216 m in Crystal Creek 1. The original boundary pick in Matches Springs 1 was apparently based on the presence of an unusual abundance of limestone in the upper Goldwyer Formation, in comparison to other wells that had been drilled at the time. Subsequent drilling has demonstrated the regional variability of carbonate–mudstone ratios in the Goldwyer Formation, and has shown that the boundary is best picked by its distinctive wireline signature rather than on the appearance of abundant carbonate.

Blackstone 1: Blackstone 1, and nearby West Blackstone 1, are the only wells on the Lennard Shelf to intersect the Nita and Goldwyer Formations. Preservation of the Ordovician section is clearly localized, as Devonian strata unconformably overlie Proterozoic basement in other wells in the area. The presence of the Nita and upper Goldwyer Formations in Blackstone 1 is indicated by sedimentary facies, conodonts assigned to the *Phragmodus–Plectodina* Zone (Nicoll, 1993), and trilobite and graptolite faunas (Legg, 1978). This study places the boundary between the Goldwyer and Nita Formations tentatively at 2311 m, substantially higher than indicated by most previous workers. The selected position is based on an attempt to match the wireline log signature with wells on the opposite side of the Fitzroy Trough, within the biostratigraphic constraints, whereas previous attempts were apparently based mainly on lithologies revealed in limited drillcore. It has not been possible to apply wireline log subdivisions of the Goldwyer Formation, as used elsewhere in the basin, to Blackstone 1. The thickness of carbonate–mudstone cycles indicated by the wireline logs suggest significantly greater rates of sedimentation in both the Nita and Goldwyer Formations in the Blackstone area, in comparison with those in other parts of the basin. This conclusion is corroborated by the biostratigraphic data of Legg (1978) which suggest that most of the intersected interval belongs to the upper Goldwyer Formation. The Nita Formation is incomplete, being overlain with an inferred erosional break by the stratotype of the Poulton Formation (Playford et al., 1975). The Poulton Formation is inferred to be of Devonian age.

Canopus 1 and Pictor 1: In these adjacent wells, the positions of the Goldwyer–Willara Formation boundary as given in the well completion reports (Ormerod and Butcher, 1983; BHP Petroleum Pty Ltd, 1984) are inconsistent with regional correlations based on wireline logs. In Canopus 1, conodonts from samples close to total depth were interpreted as belonging to the *Prioniodus elegans – Bergstroemognathus extensus* Zone, whereas those just above were assigned to the *Oepikodus communis* Zone (Savage, 1983). These zones are normally associated with the Nambeet and Lower Willara Formations respectively, although Nicoll (1993) casts some doubt on the quality of the identifications. The putative presence of these zones near the bottom of this well apparently led to the placement of the Goldwyer–Willara Formation contact at a position above that in other wells. On the balance of all available data, and pending any reassessment of the biostratigraphy, it is suggested that the Goldwyer–Willara Formation boundary in Canopus 1 be lowered to 1750 m, and it is inferred that this hole was terminated near the top of the Willara Formation. In Pictor 1, the Goldwyer–Willara Formation boundary as picked by BHP Petroleum (1984) was apparently selected by direct correlation to the incorrect position in nearby Canopus 1. From regional wireline log correlations and conodont biostratigraphic data (Nicoll, 1993) the Goldwyer–Willara Formation boundary in Pictor 1 should be lowered to 1514 m.

Wilson Cliffs 1 and Contention Heights 1: These wells are near the eastern end of the basin and are remote from other wells intersecting the Ordovician section. Previous investigations have concluded that the Nita Formation is absent in both wells, and that the Goldwyer Formation conformably overlies the Wilson Cliffs Sandstone. The latter unit is interpreted as a sandy age-equivalent of the Willara and Nambeet Formations (McTavish and Legg, 1976). Based on available lithological and conodont biostratigraphic evidence, and correlations to the nearest well (Percival 1), this study concludes that the Nita Formation is present, although reduced in thickness. Thinning and amalgamation of the carbonate–mudstone cycles typical of the Nita Formation elsewhere means that formation boundaries can only be placed approximately, based on wireline signatures. The contact between the Goldwyer Formation and Wilson Cliffs Sandstone is well defined, although gradational in the stratotype of the latter unit in Wilson Cliffs 1 (at 2847 m by definition; McTavish and Legg, 1976). In Contention Heights 1 the gamma-ray log stops at 1580 m, and the base of the Goldwyer Formation was put at this position by Brown and Campbell (1974). The interval 1463–1494 m contains conodonts indicative of the *Histiodella holodentata* Zone (normally found in the lower Goldwyer – uppermost Willara Formations), and the interval 1494–1585 m contains conodonts tentatively assigned to the *Jumudontus gananda* Zone (Nicoll, 1993). If the latter zone identification is correct, what has been identified as Goldwyer Formation includes equivalents of the upper Willara Formation.

References

BHP PETROLEUM PTY LTD, 1984, Pictor 1 well completion report: Western Australia Geological Survey, Statutory petroleum exploration report, S2607 A6 (unpublished).

BROWN, R., and CAMPBELL, N., 1974, Contention Heights 1 well completion report: Western Australia Geological Survey, Statutory petroleum exploration report, S874 A3 (unpublished).

BURNE, R. V., GORTER, J. D., and PASSMORE, V. L., (compilers) 1981, Appendices: Stratigraphic units of intervals 1 to 11, *in* Geological evolution of the Canning Basin, Western Australia *by* D. J. FORMAN and D. W. WALES, Australia Bureau of Mineral Resources, Bulletin 210, BMR Microform MF170.

COMMAND PETROLEUM NL, 1989, Frankenstein 1 well completion report: Western Australia Geological Survey, Statutory petroleum exploration report, S3417 A2 (unpublished).

LEGG, D. P., 1978, Ordovician biostratigraphy of the Canning Basin, Western Australia: Alcheringa, v. 2, p. 321–334.

McTAVISH, R. A., and LEGG, D. P., 1976, The Ordovician of the Canning Basin, Western Australia, *in* The Ordovician System: Proceedings of a Palaeontological Association symposium, Birmington, September 1974 *edited by* M. G. BASSETT: University of Wales Press and National Museum of Wales, Cardiff, p. 447–478.

NICOLL, R. S., 1993, Ordovician conodont distribution in selected petroleum exploration wells, Canning Basin, Western Australia: Australian Geological Survey Organisation, Record 1993/17, 136p.

ORMEROD, P. C., and BUTCHER, B., 1983, Canopus 1 well completion report: Western Australia Geological Survey, Statutory petroleum exploration report, S2166 A2 (unpublished).

PLAYFORD, P. E., COPE, R. N., COCKBAIN, A. E., LOW, G. H., and LOWRY, D. C., 1975, Phanerozoic, *in* The Geology of Western Australia: Western Australia Geological Survey, Memoir 2, p. 223–433.

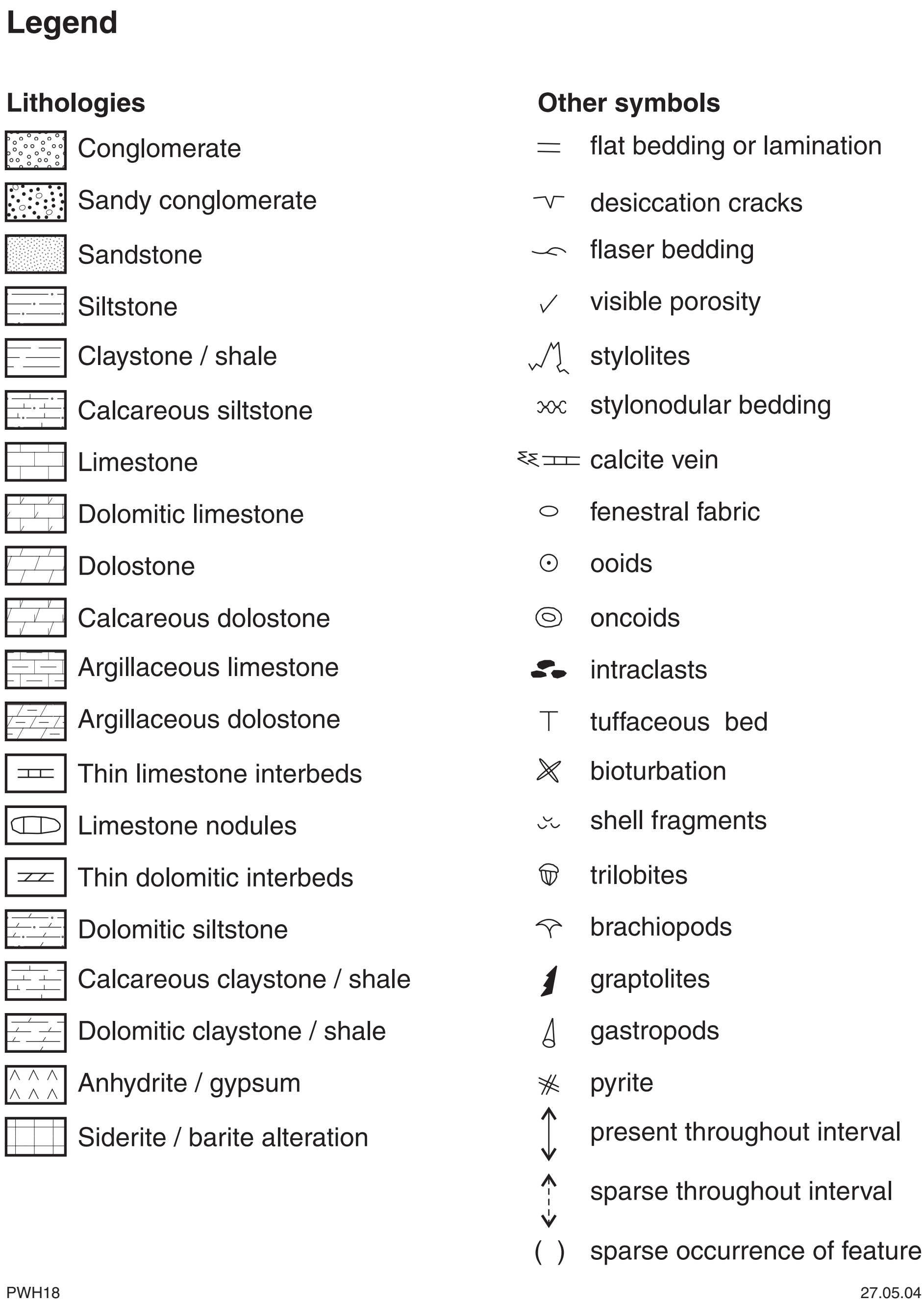
PURCELL, R. R., 1989, Palynological report, Frankenstein 1, *in* Command Petroleum NL, Frankenstein 1 well completion report: Western Australia Geological Survey, Statutory petroleum exploration report, S3417 A2 V2 (unpublished).

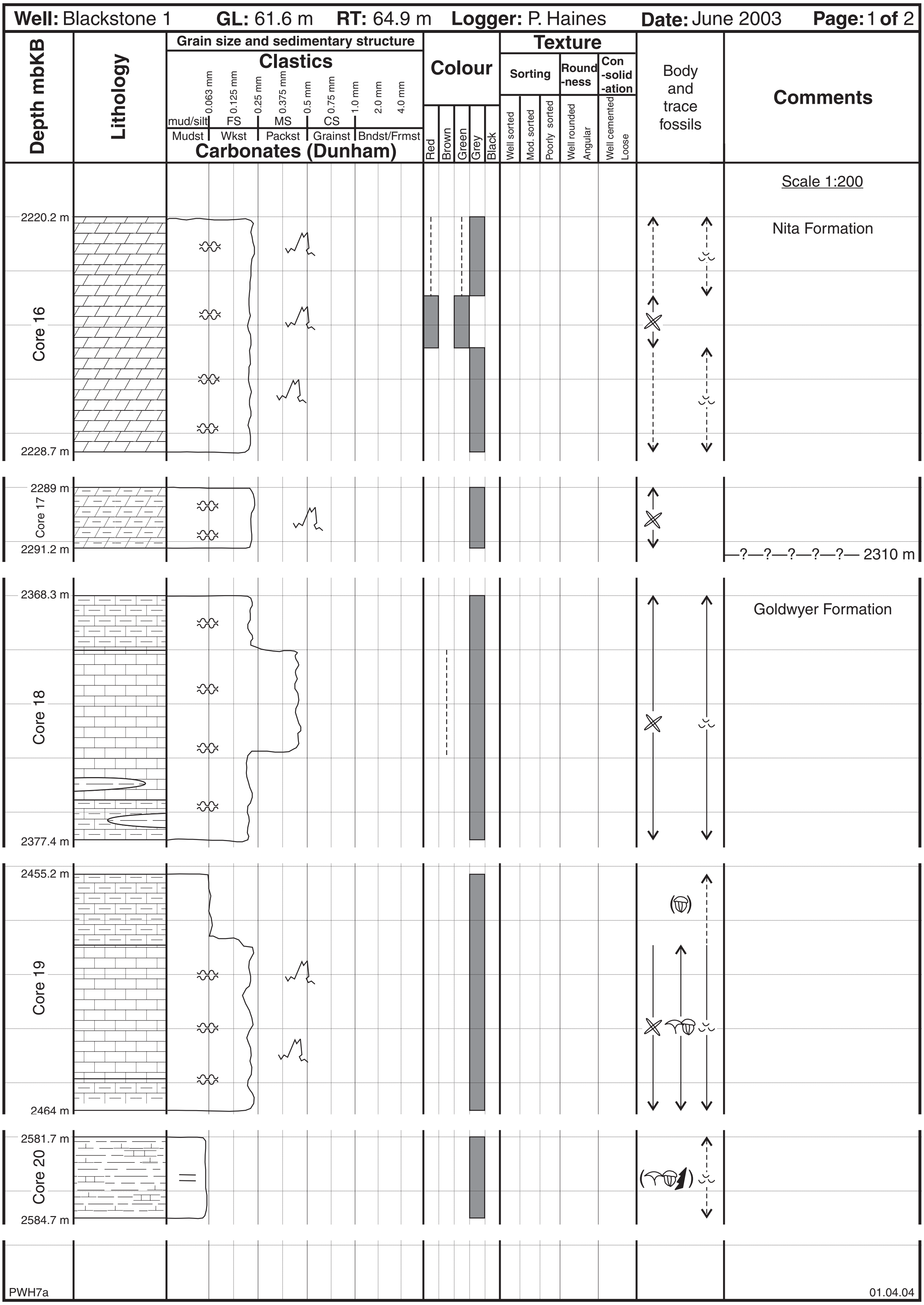
SAVAGE, N. M., 1983, Final report: Conodont dating/thermal maturation of Canopus No. 1, interval 1065–1775 m (71 samples), *in* Canopus 1 well completion report *compiled by* P. C. ORMEROD and B. BUTCHER: Western Australia Geological Survey, Statutory petroleum exploration report, S2166 A2 (unpublished).

TOWNER, R. R., and GIBSON, D. L., 1983, Geology of the onshore Canning Basin, Western Australia: Australia BMR, Bulletin 215, 51p.

Appendix 5

Graphic logs of selected drillcore





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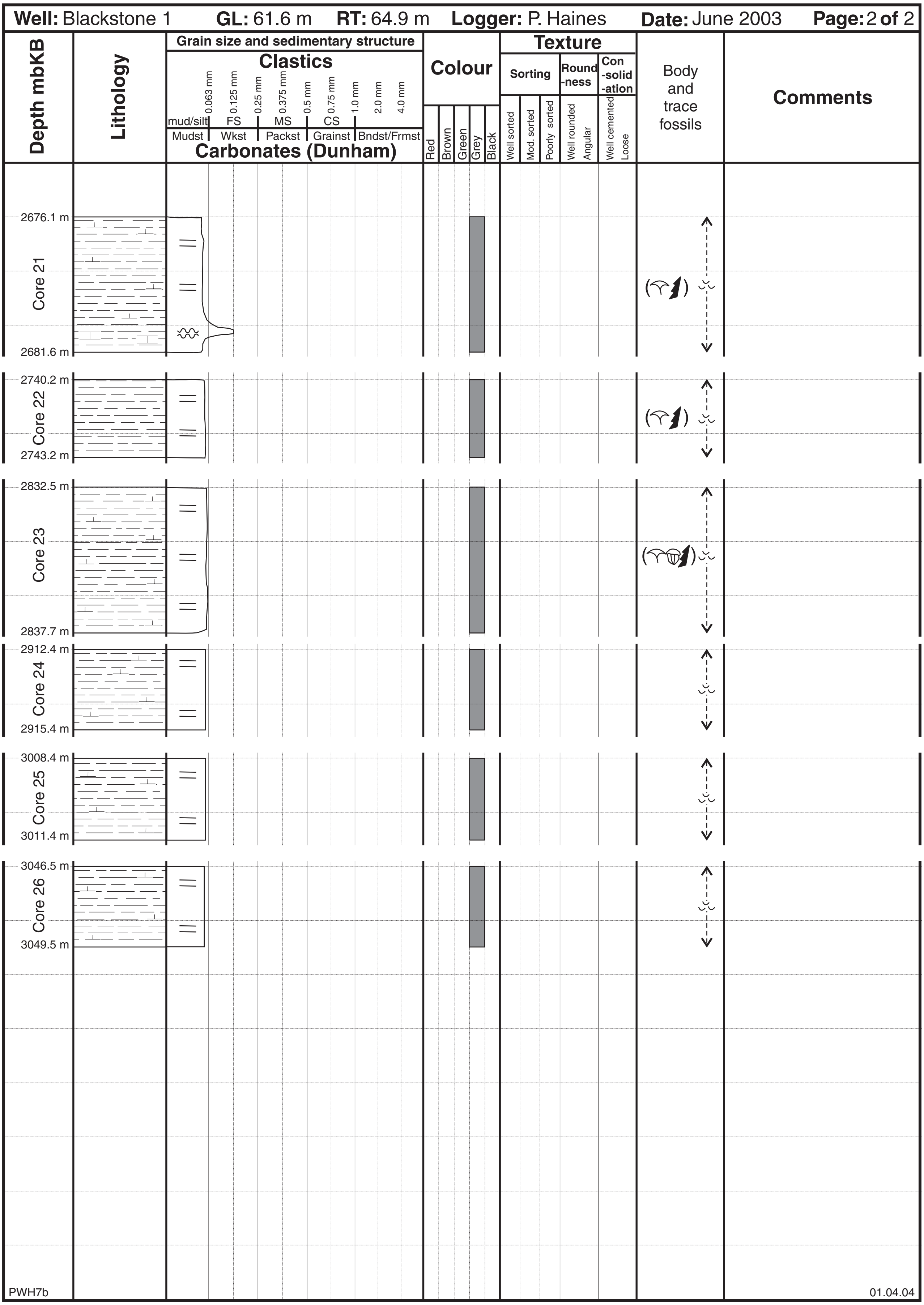
Lithology
Grain size and sedimentary structure
Clastics
0.063 mm
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt FS MS CS
Mudst Wkst Packst Grainst Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Well sorted
Mod. sorted
Poorly sorted
Round -ness
Well rounded
Angular
Con -solid -ation
Well cemented
Loose
Body and trace fossils
Comments
Scale 1:200
2220.2 m
Core 16
2228.7 m
Nita Formation
2289 m
Core 17
2291.2 m
—?—?—?—?—?— 2310 m
2368.3 m
Core 18
2377.4 m
Goldwyer Formation
2455.2 m
Core 19
2464 m
2581.7 m
Core 20
2584.7 m
PWH7a
01.04.04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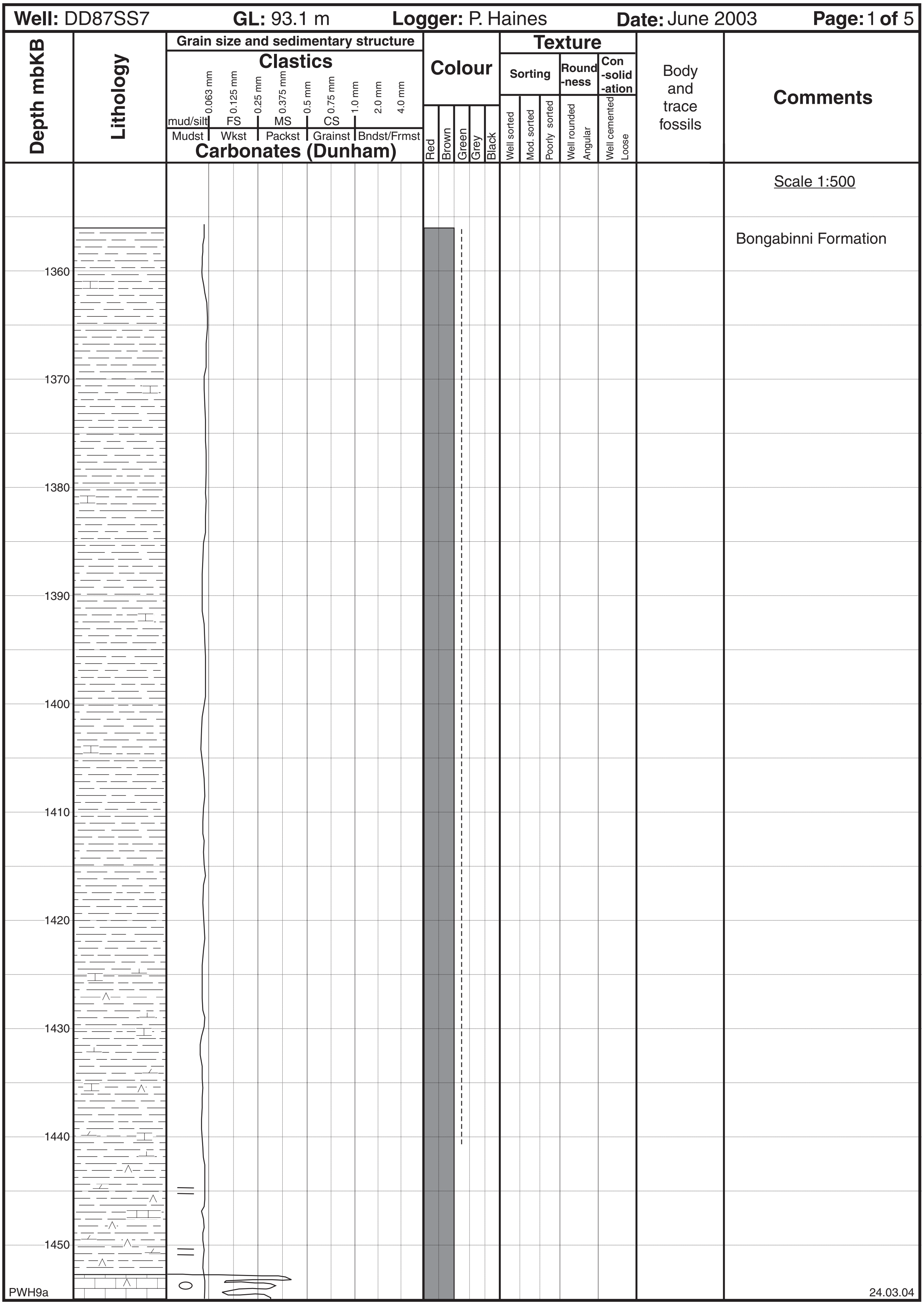
Depth mbKB
Lithology
Grain size and sedimentary structure
Clastics
0.063 mm
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt FS MS CS
Mudst Wkst Packst Grainst Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Round -ness
Con -solid -ation
Well sorted
Mod. sorted
Poorly sorted
Well rounded
Angular
Well cemented
Loose
Body and trace fossils
Comments
2676.1 m
Core 21
2681.6 m
2740.2 m
Core 22
2743.2 m
2832.5 m
Core 23
2837.7 m
2912.4 m
Core 24
2915.4 m
3008.4 m
Core 25
3011.4 m
3046.5 m
Core 26
3049.5 m
PWH7b
01.04.04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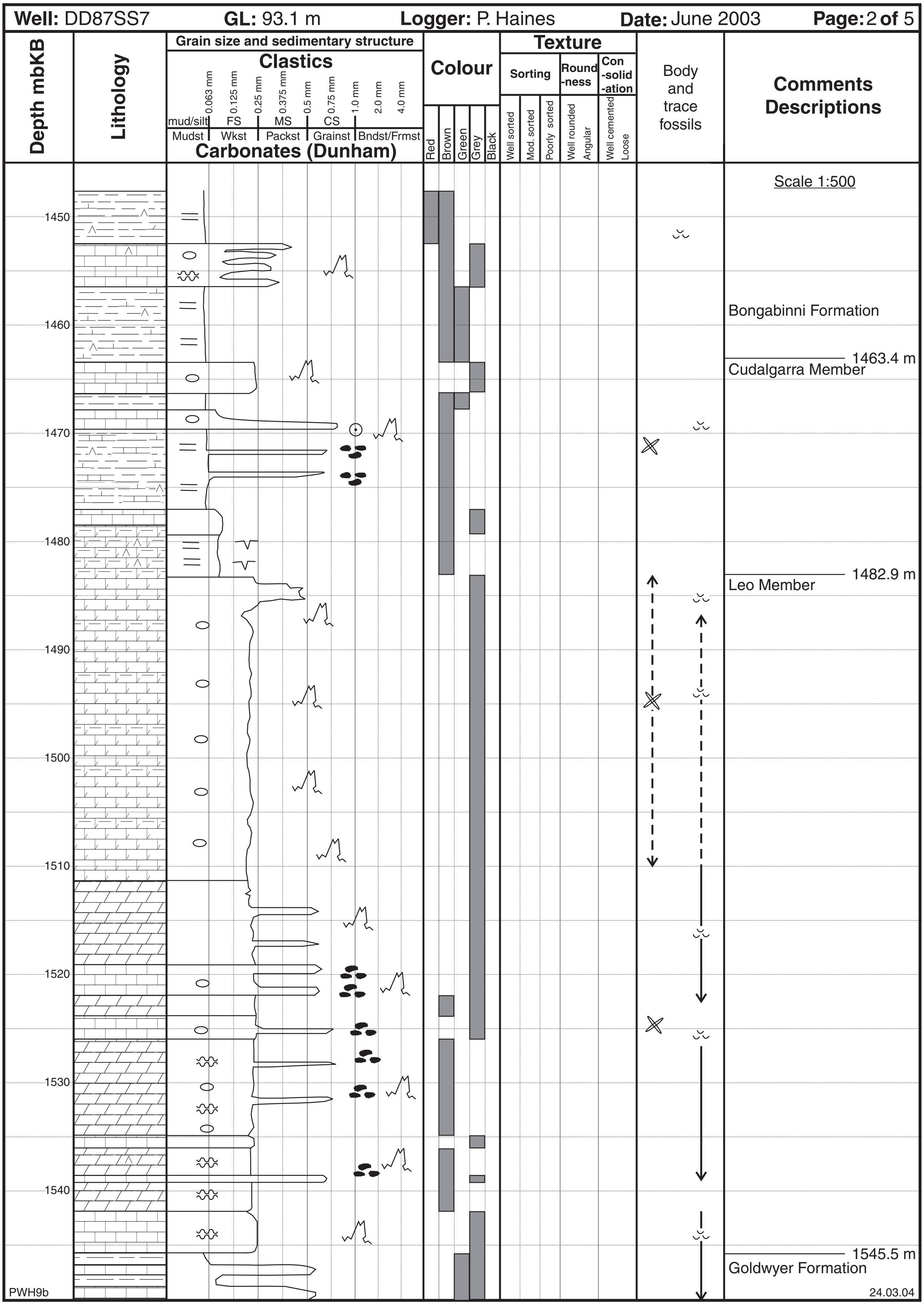
GL: 93.1 m
Logger: P. Haines
Date: June 2003
Page: 1 of 5
Depth mbKB
Lithology
Grain size and sedimentary structure
Clastics
0.063 mm
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt
FS
MS
CS
Mudst
Wkst
Packst
Grainst
Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Well sorted
Mod. sorted
Poorly sorted
Round -ness
Well rounded
Angular
Con -solid -ation
Well cemented
Loose
Body and trace fossils
Comments
Scale 1:500
Bongabinni Formation
1360
1370
1380
1390
1400
1410
1420
1430
1440
1450
PWH9a
24.03.04


Well: DD87SS7
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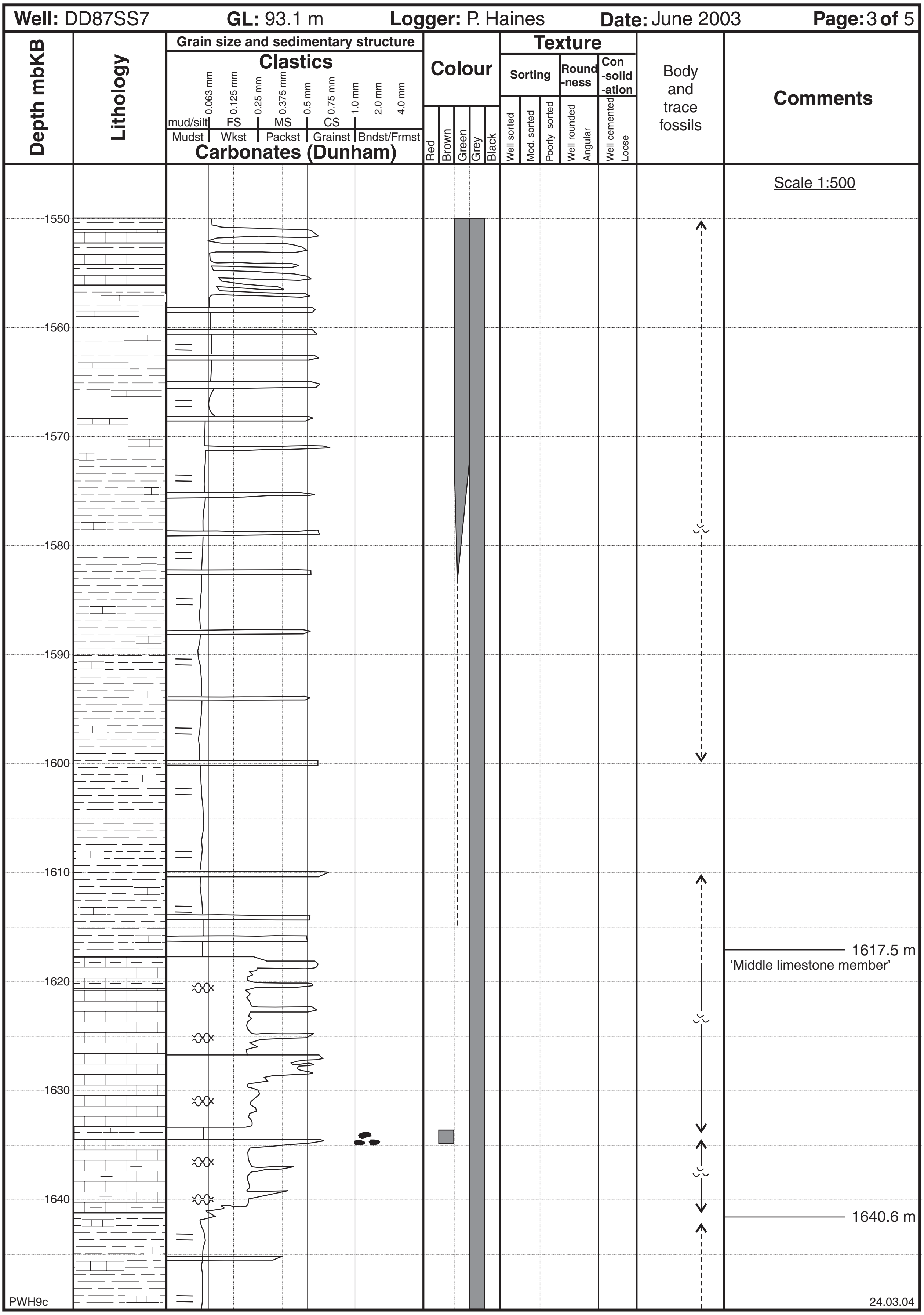
Logger: P. Haines
Date: June 2003
Page: 2 of 5
Depth mbKB
Lithology
Grain size and sedimentary structure
Clastics
0.063 mm
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt
FS
MS
CS
Mudst
Wkst
Packst
Grainst
Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Round -ness
Con -solid -ation
Well sorted
Mod. sorted
Poorly sorted
Well rounded
Angular
Well cemented
Loose
Body and trace fossils
Comments Descriptions
Scale 1:500
1450
1460
1470
1480
1490
1500
1510
1520
1530
1540
Bongabinni Formation
1463.4 m
Cudalgarra Member
1482.9 m
Leo Member
1545.5 m
Goldwyer Formation
PWH9b
24.03.04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Date: June 2003
Page: 3 of 5
Depth mbKB
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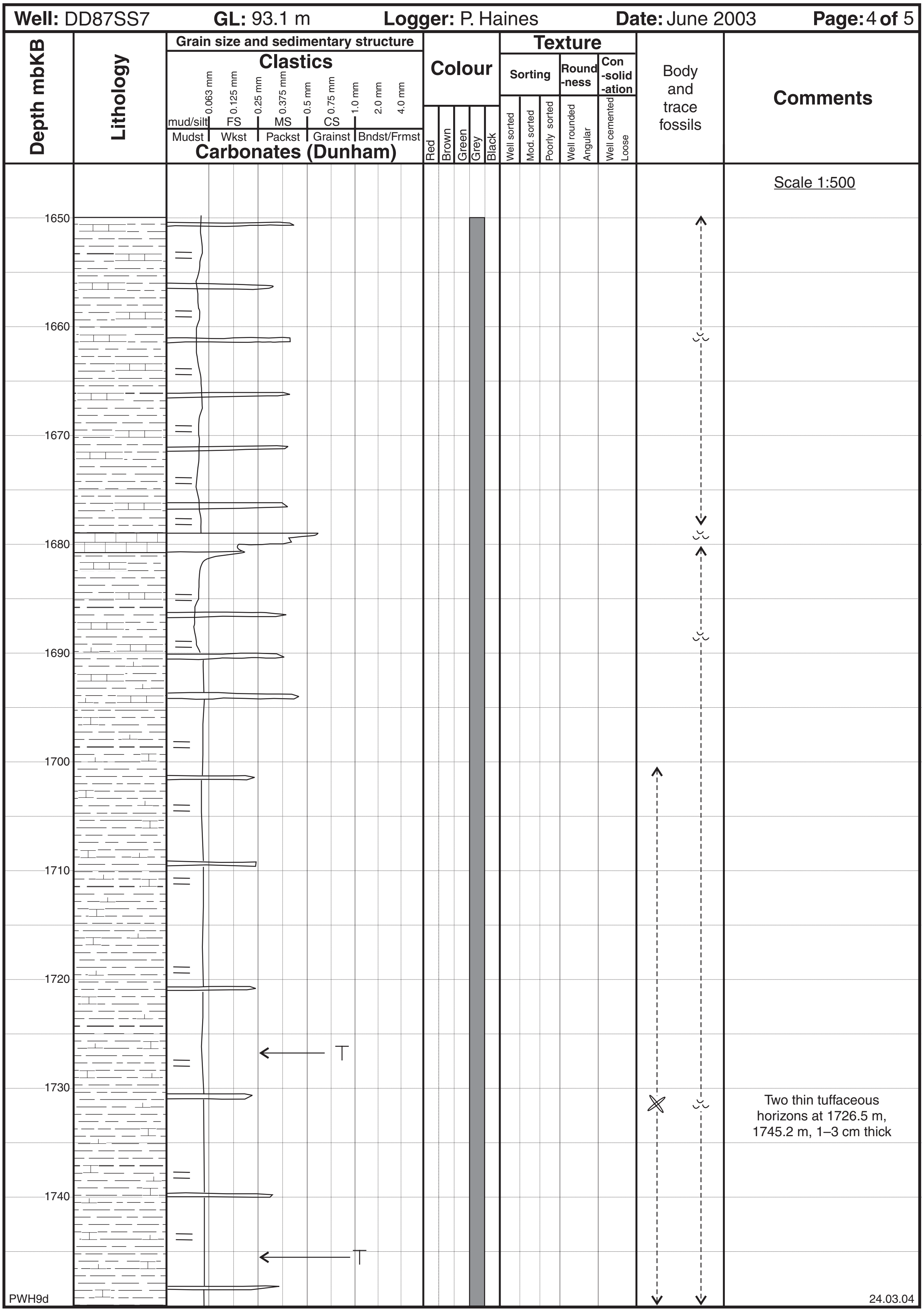
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt
FS
MS
CS
Mudst
Wkst
Packst
Grainst
Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Well sorted
Mod. sorted
Poorly sorted
Round -ness
Well rounded
Angular
Con -solid -ation
Well cemented
Loose
Body and trace fossils
Comments
Scale 1:500
1550
1560
1570
1580
1590
1600
1610
1620
1630
1640
1617.5 m
'Middle limestone member'
1640.6 m
PWH9c
24.03.04


Well: DD87SS7
GL: 93.1 m
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Date: June 2003
Page: 4 of 5
Depth mbKB
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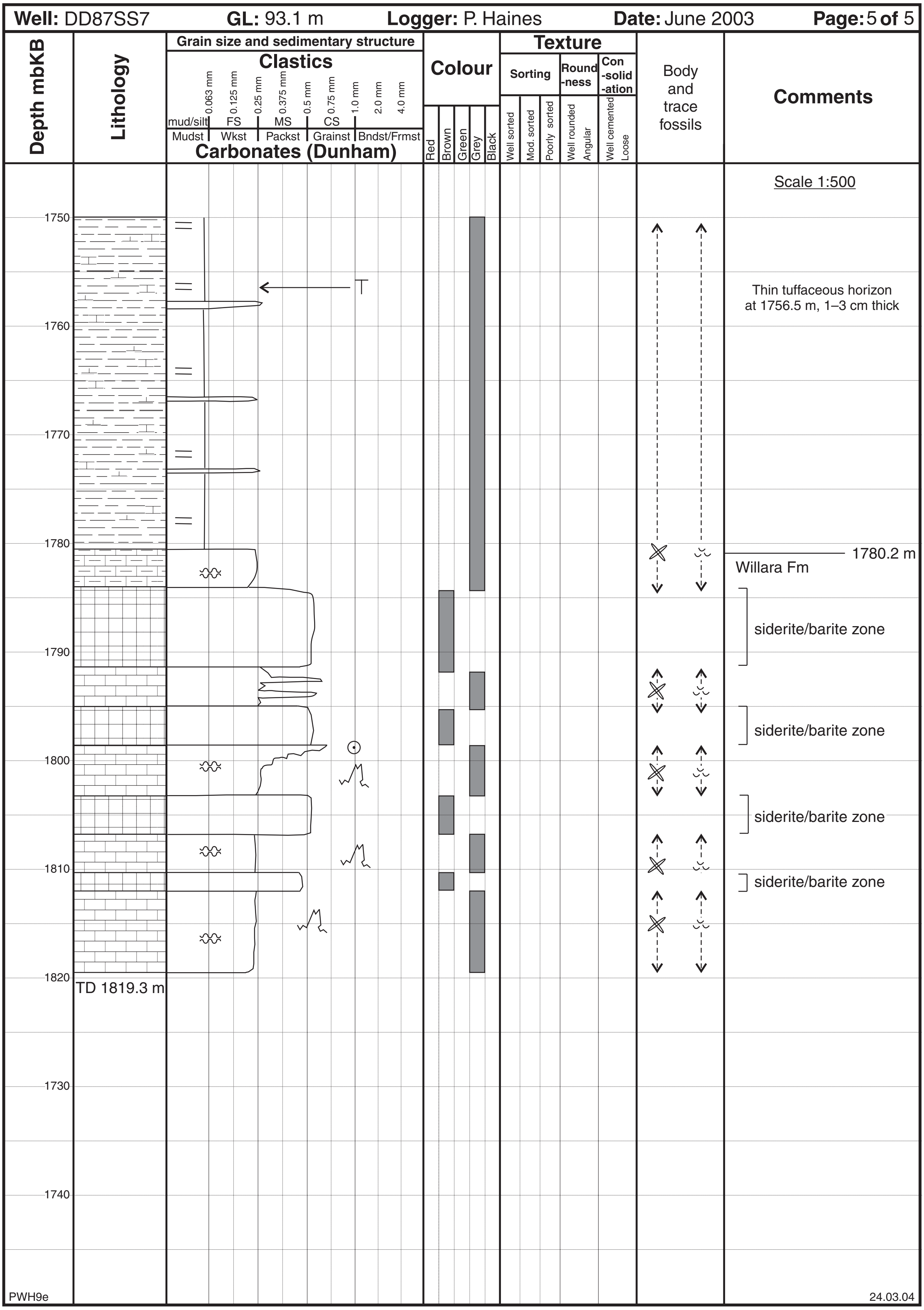
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt
FS
MS
CS
Mudst
Wkst
Packst
Grainst
Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Well sorted
Mod. sorted
Poorly sorted
Round -ness
Well rounded
Angular
Con -solid -ation
Well cemented
Loose
Body and trace fossils
Comments
Scale 1:500
1650
1660
1670
1680
1690
1700
1710
1720
1730
1740
T
T
Two thin tuffaceous horizons at 1726.5 m, 1745.2 m, 1–3 cm thick
PWH9d
24.03.04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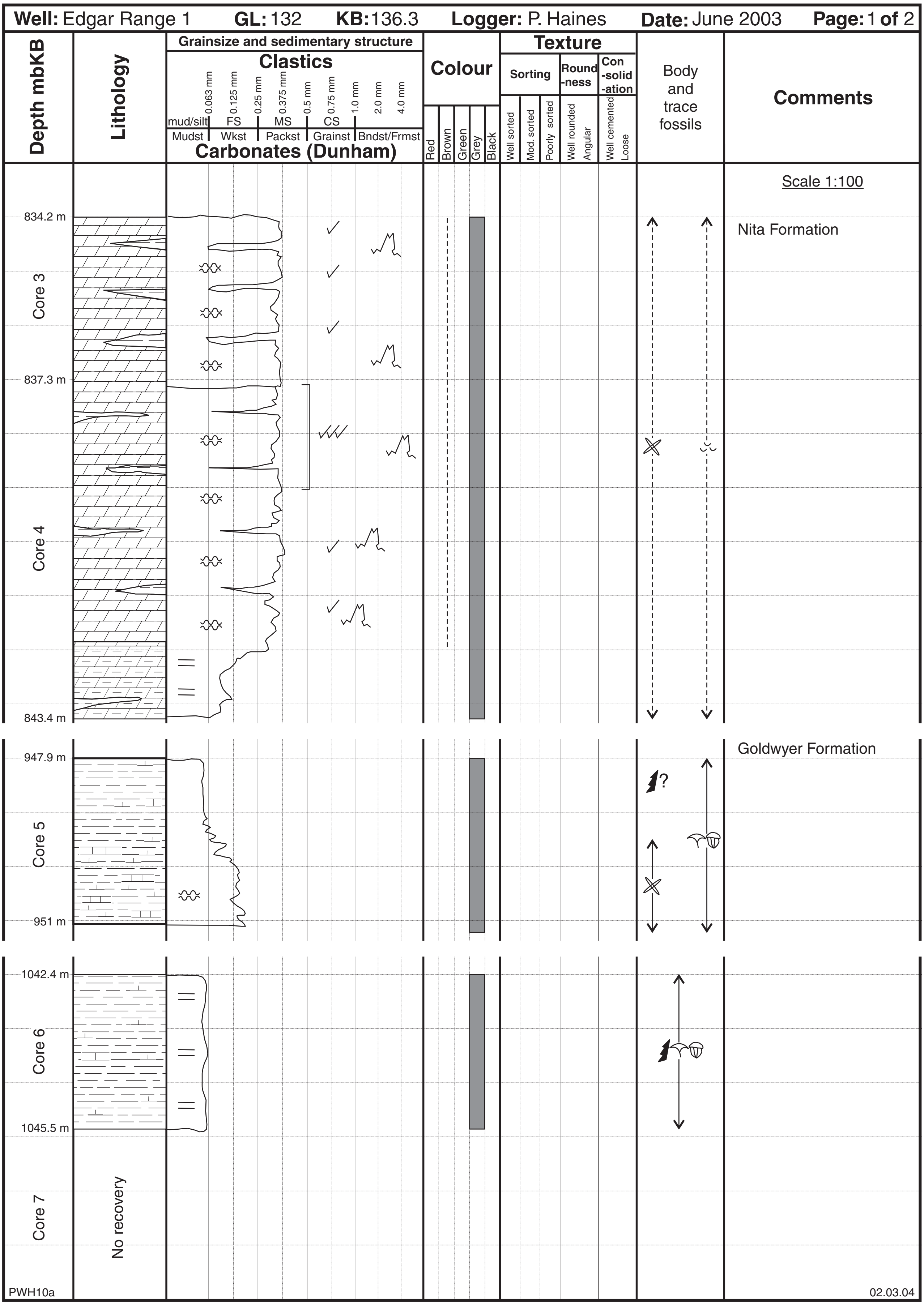
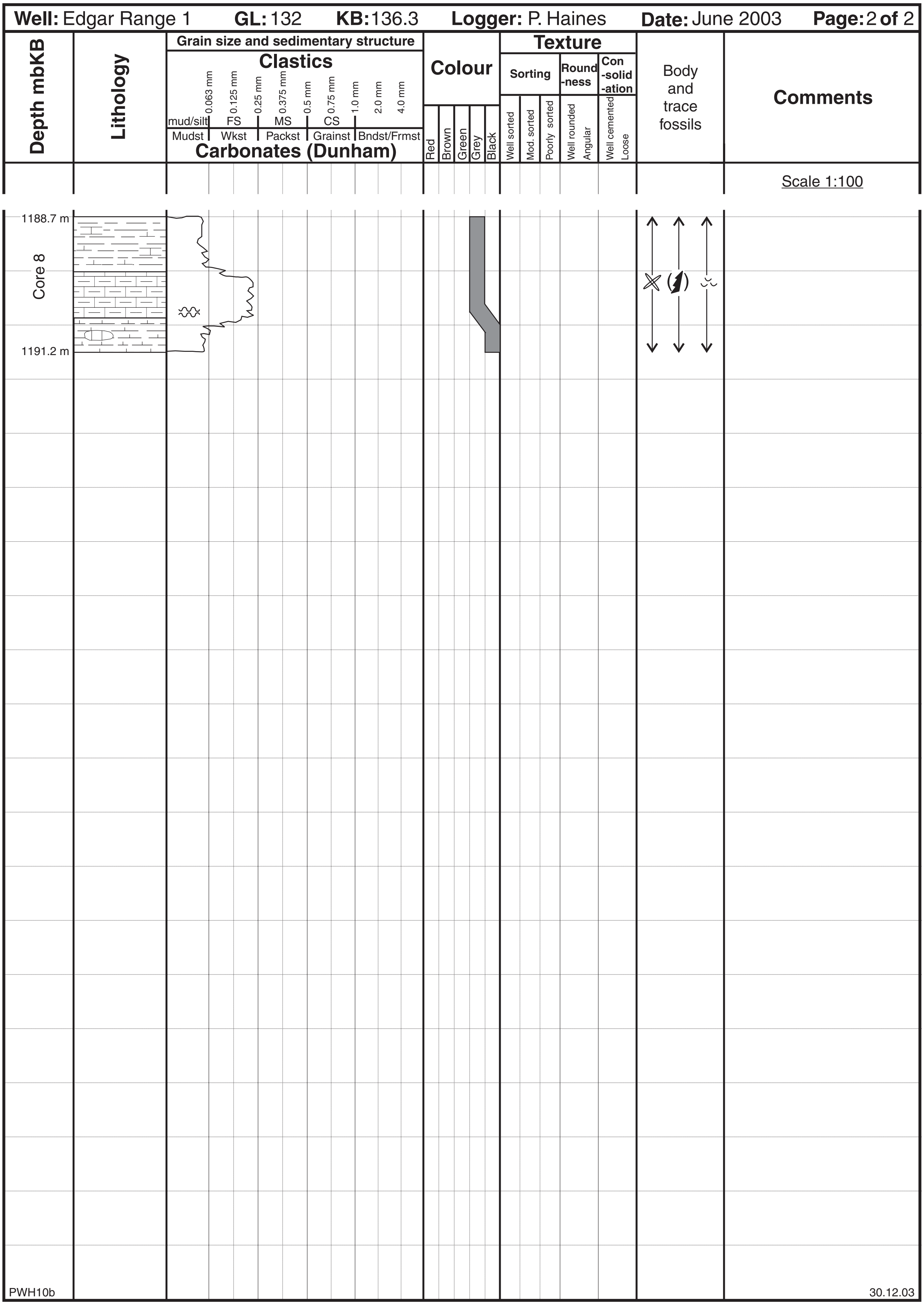
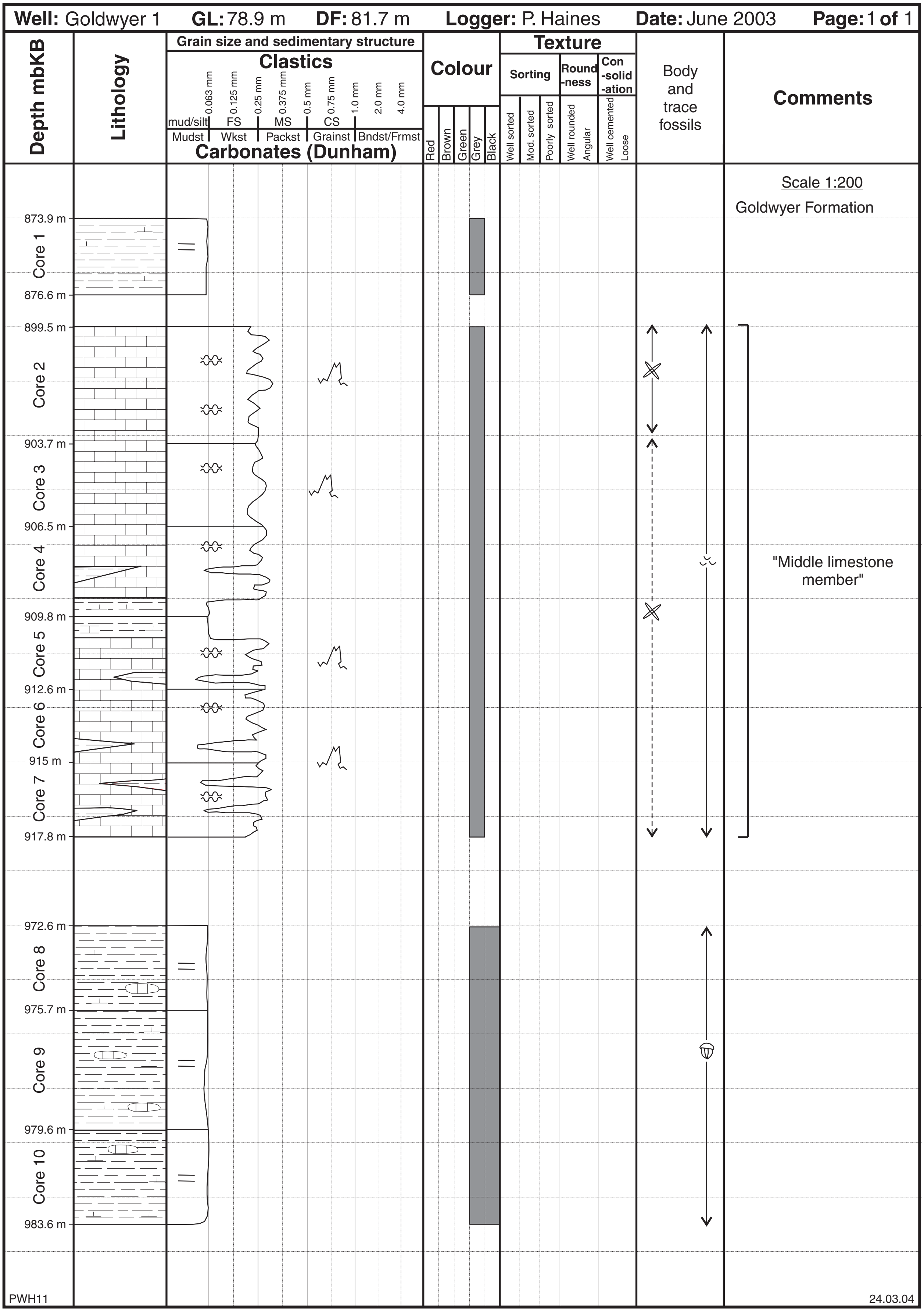
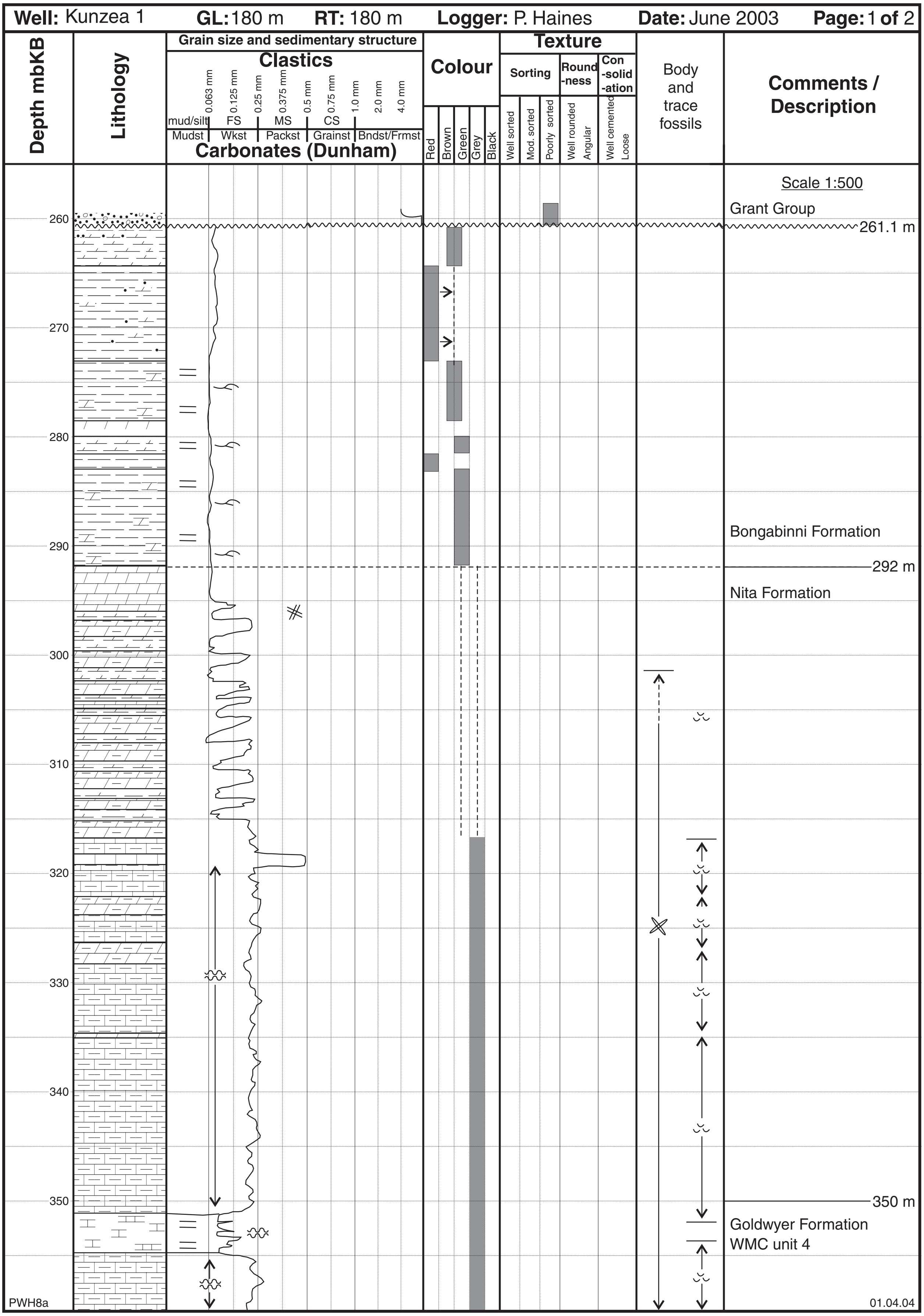
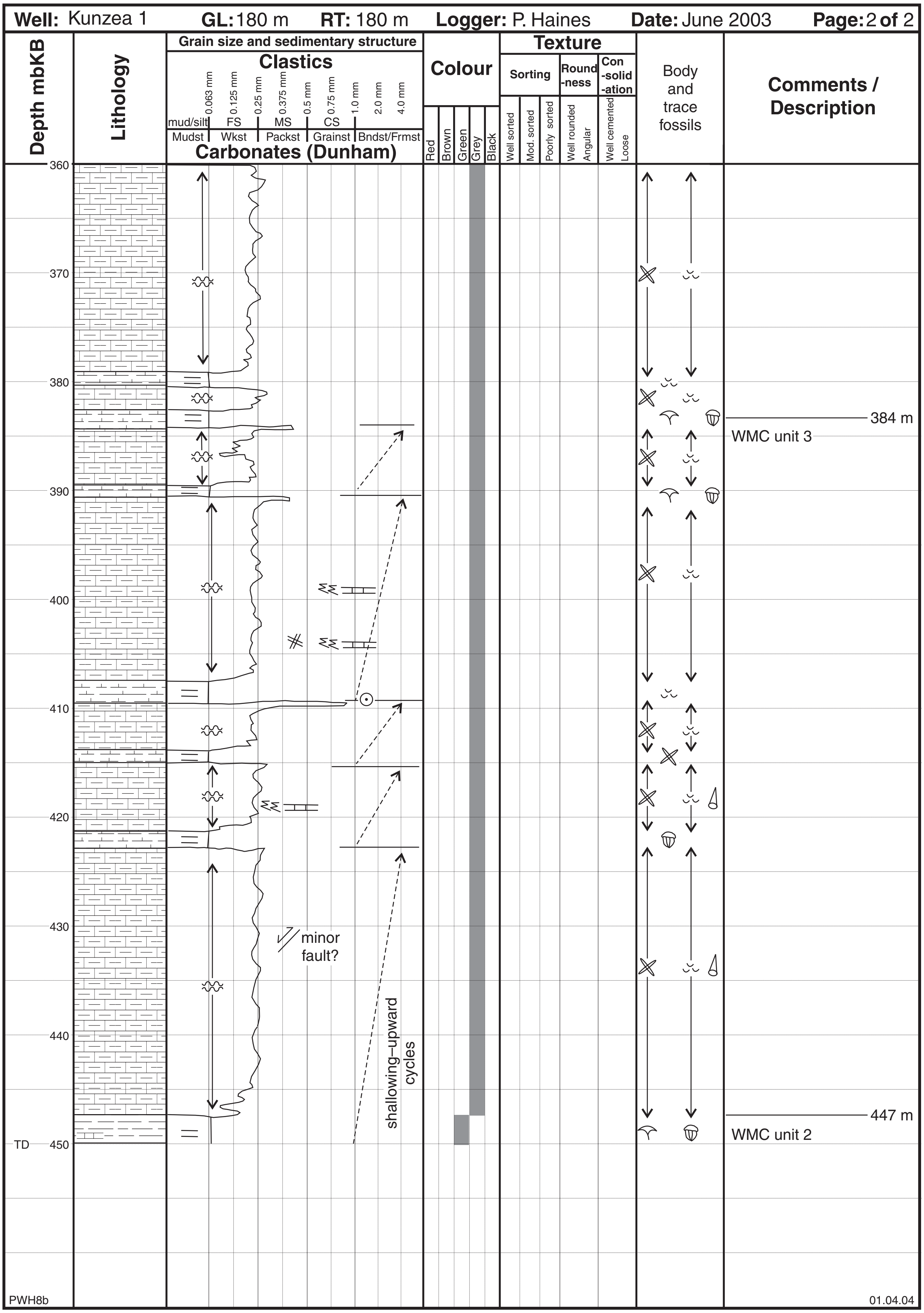
Date: June 2003
Page: 5 of 5
Depth mbKB
Lithology
Grain size and sedimentary structure
Clastics
0.063 mm
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt
FS
MS
CS
Mudst
Wkst
Packst
Grainst
Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Well sorted
Mod. sorted
Poorly sorted
Round -ness
Well rounded
Angular
Con -solid -ation
Well cemented
Loose
Body and trace fossils
Comments
Scale 1:500
1750
1760
1770
1780
1790
1800
1810
1820
1730
1740
T
Thin tuffaceous horizon at 1756.5 m, 1–3 cm thick
1780.2 m
Willara Fm
siderite/barite zone
siderite/barite zone
siderite/barite zone
siderite/barite zone
TD 1819.3 m
PWH9e
24.03.04

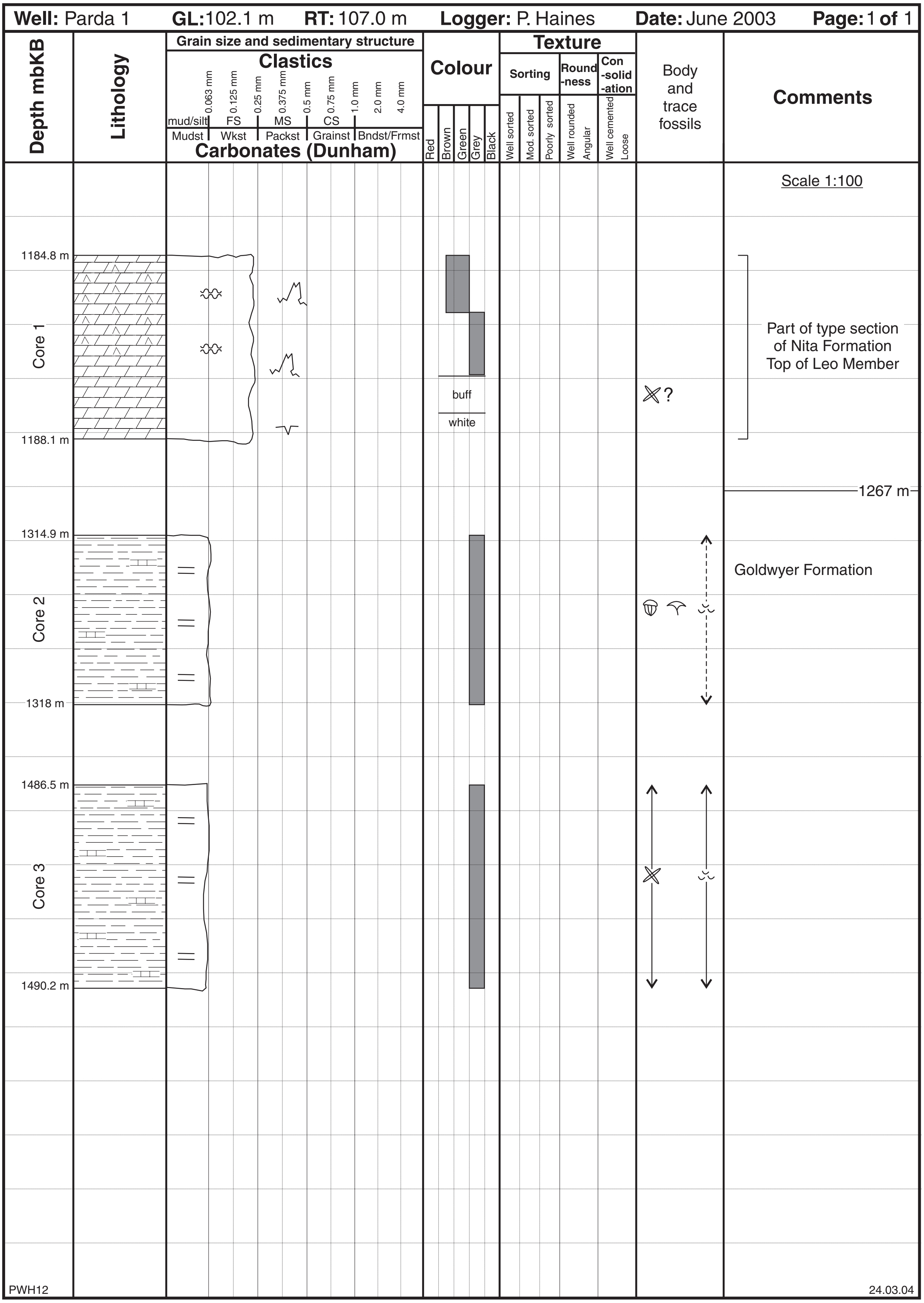

Well: Edgar Range 1
GL: 132
KB: 136.3
Logger: P. Haines
Date: June 2003
Page: 1 of 2
Depth mbKB
Lithology
Grainsize and sedimentary structure
Clastics
0.063 mm
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt
FS
MS
CS
Mudst
Wkst
Packst
Grainst
Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Well sorted
Mod. sorted
Poorly sorted
Round-ness
Well rounded
Angular
Con-solid-ation
Well cemented
Loose
Body and trace fossils
Comments
Scale 1:100
834.2 m
Core 3
837.3 m
Core 4
843.4 m
Nita Formation
947.9 m
Core 5
951 m
Goldwyer Formation
?
1042.4 m
Core 6
1045.5 m
Core 7
No recovery
PWH10a
02.03.04


Well: Edgar Range 1
GL: 132
KB: 136.3
Logger: P. Haines
Date: June 2003
Page: 2 of 2
Depth mbKB
Lithology
Grain size and sedimentary structure
Clastics
0.063 mm
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt
FS
MS
CS
Mudst
Wkst
Packst
Grainst
Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Well sorted
Mod. sorted
Poorly sorted
Round -ness
Well rounded
Angular
Con -solid -ation
Well cemented
Loose
Body and trace fossils
Comments
Scale 1:100
1188.7 m
Core 8
1191.2 m
PWH10b
30.12.03


Well: Goldwyer 1
GL: 78.9 m
DF: 81.7 m
Logger: P. Haines
Date: June 2003
Page: 1 of 1
Depth mbKB
Lithology
Grain size and sedimentary structure
Clastics
0.063 mm
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt
FS
MS
CS
Mudst
Wkst
Packst
Grainst
Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Well sorted
Mod. sorted
Poorly sorted
Round -ness
Well rounded
Angular
Con -solid -ation
Well cemented
Loose
Body and trace fossils
Comments
Scale 1:200
Goldwyer Formation
873.9 m
Core 1
876.6 m
899.5 m
Core 2
903.7 m
Core 3
906.5 m
Core 4
909.8 m
Core 5
912.6 m
Core 6
915 m
Core 7
917.8 m
"Middle limestone member"
972.6 m
Core 8
975.7 m
Core 9
979.6 m
Core 10
983.6 m
PWH11
24.03.04


Well: Kunzea 1
GL: 180 m
RT: 180 m
Logger: P. Haines
Date: June 2003
Page: 1 of 2
Depth mbKB
Lithology
Grain size and sedimentary structure
Clastics
0.063 mm
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt
FS
MS
CS
Mudst
Wkst
Packst
Grainst
Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Well sorted
Mod. sorted
Poorly sorted
Round-ness
Well rounded
Angular
Con-solid-ation
Well cemented
Loose
Body and trace fossils
Comments / Description
Scale 1:500
Grant Group
261.1 m
Bongabinni Formation
292 m
Nita Formation
350 m
Goldwyer Formation
WMC unit 4
260
270
280
290
300
310
320
330
340
350
PWH8a
01.04.04


Well: Kunzea 1
GL: 180 m
RT: 180 m
Logger: P. Haines
Date: June 2003
Page: 2 of 2
Depth mbKB
Lithology
Grain size and sedimentary structure
Clastics
0.063 mm
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt
FS
MS
CS
Mudst
Wkst
Packst
Grainst
Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Well sorted
Mod. sorted
Poorly sorted
Round-ness
Well rounded
Angular
Con-solid-ation
Well cemented
Loose
Body and trace fossils
Comments / Description
360
370
380
390
400
410
420
430
440
TD
450
384 m
WMC unit 3
447 m
WMC unit 2
minor fault?
shallowing–upward cycles
PWH8b
01.04.04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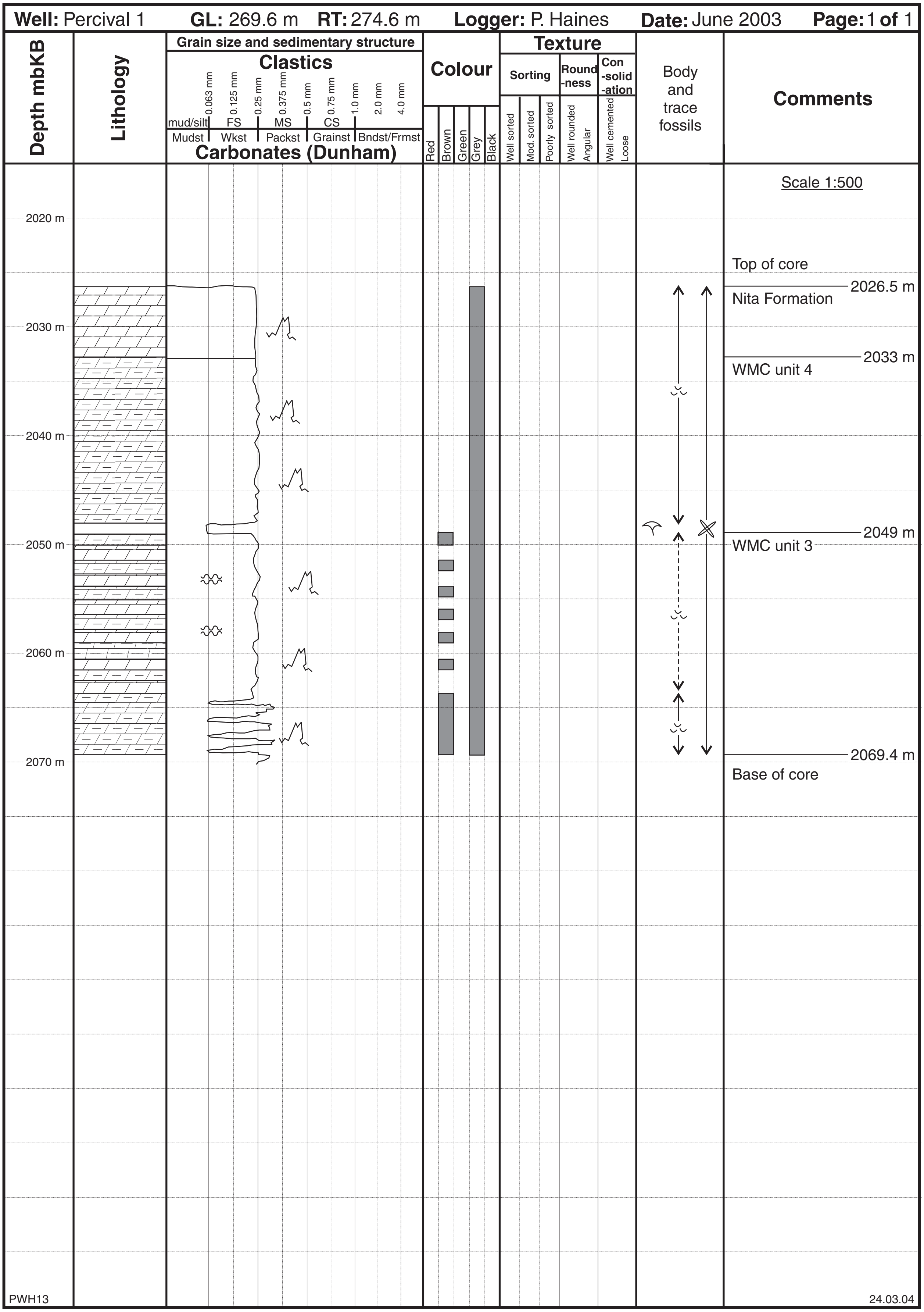
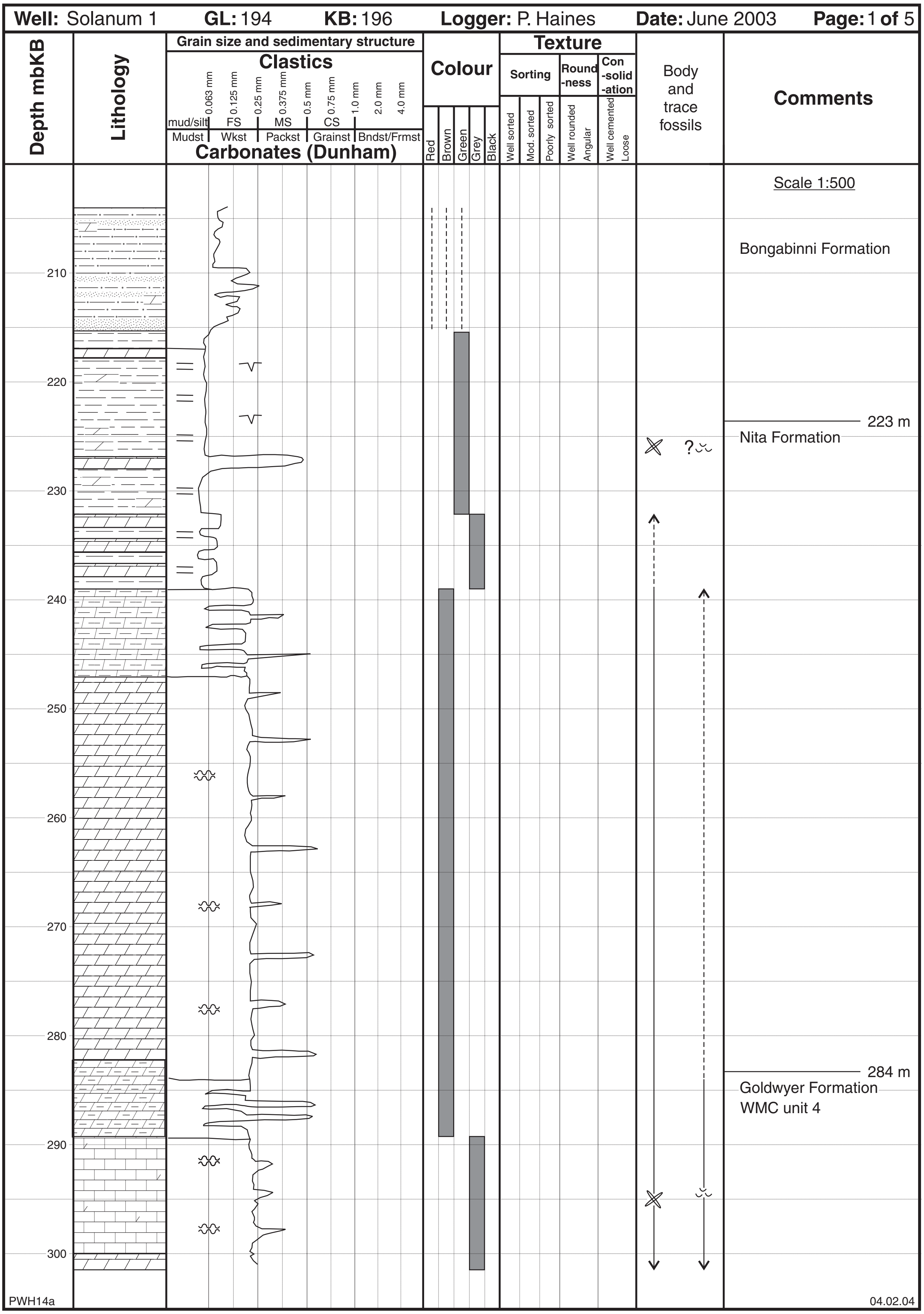
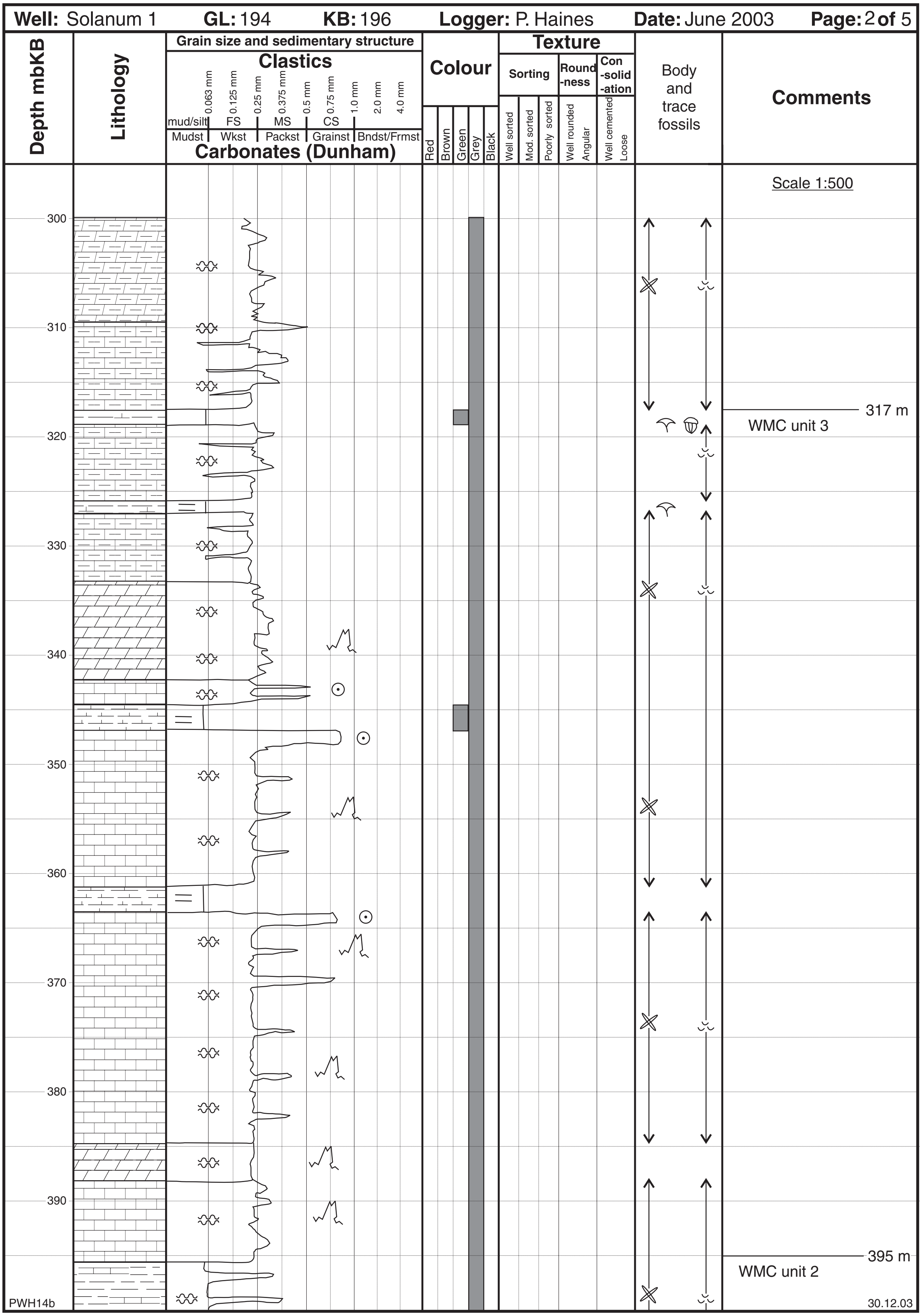
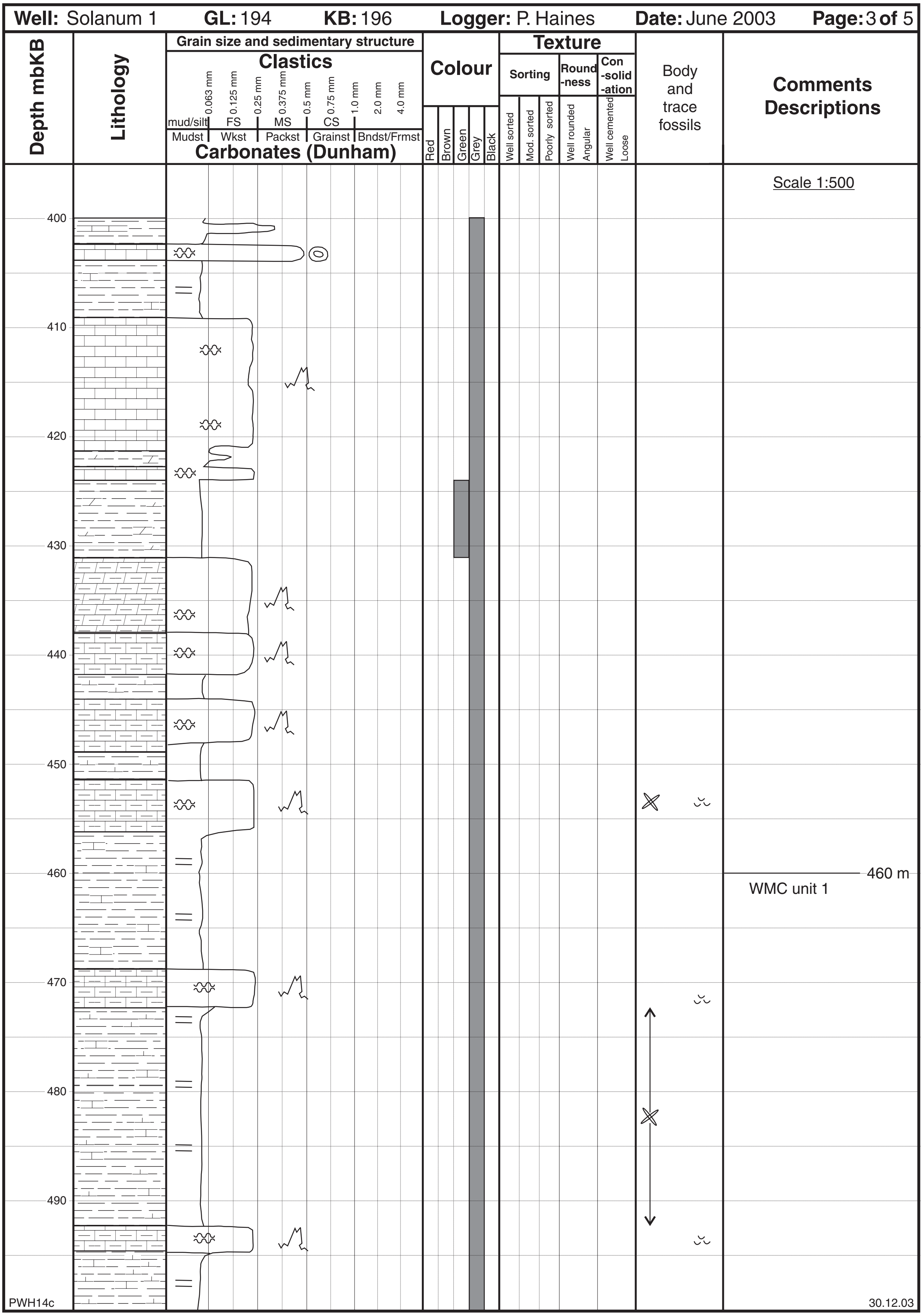
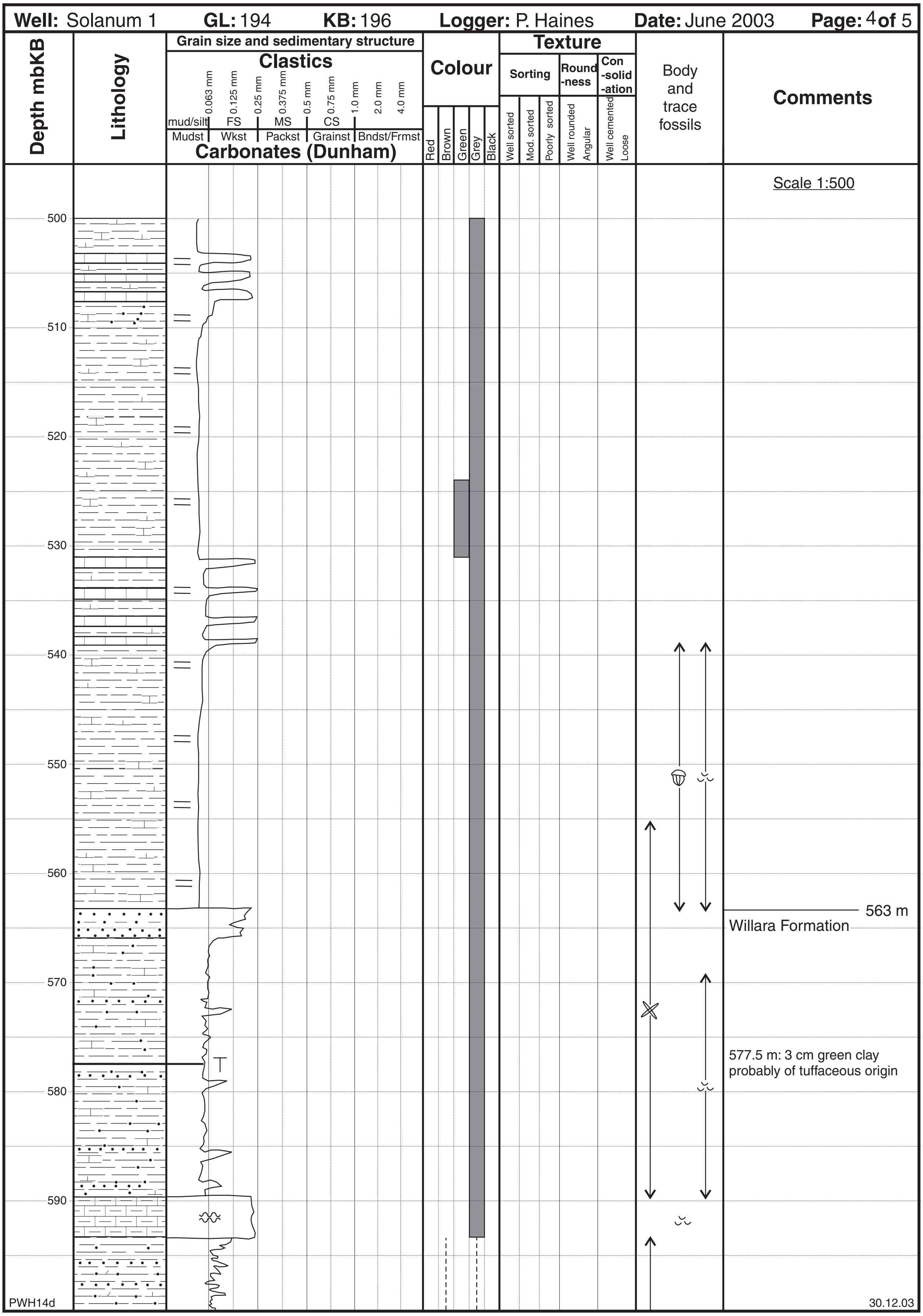
GL: 102.1 m
RT: 107.0 m
Logger: P. Haines
Date: June 2003
Page: 1 of 1
Depth mbKB
Lithology
Grain size and sedimentary structure
Clastics
0.063 mm
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt
FS
MS
CS
Mudst
Wkst
Packst
Grainst
Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Well sorted
Mod. sorted
Poorly sorted
Round -ness
Well rounded
Angular
Con -solid -ation
Well cemented
Loose
Body and trace fossils
Comments
Scale 1:100
1184.8 m
Core 1
1188.1 m
buff
white
Part of type section of Nita Formation Top of Leo Member
1267 m
1314.9 m
Core 2
1318 m
Goldwyer Formation
1486.5 m
Core 3
1490.2 m
PWH12
24.03.04

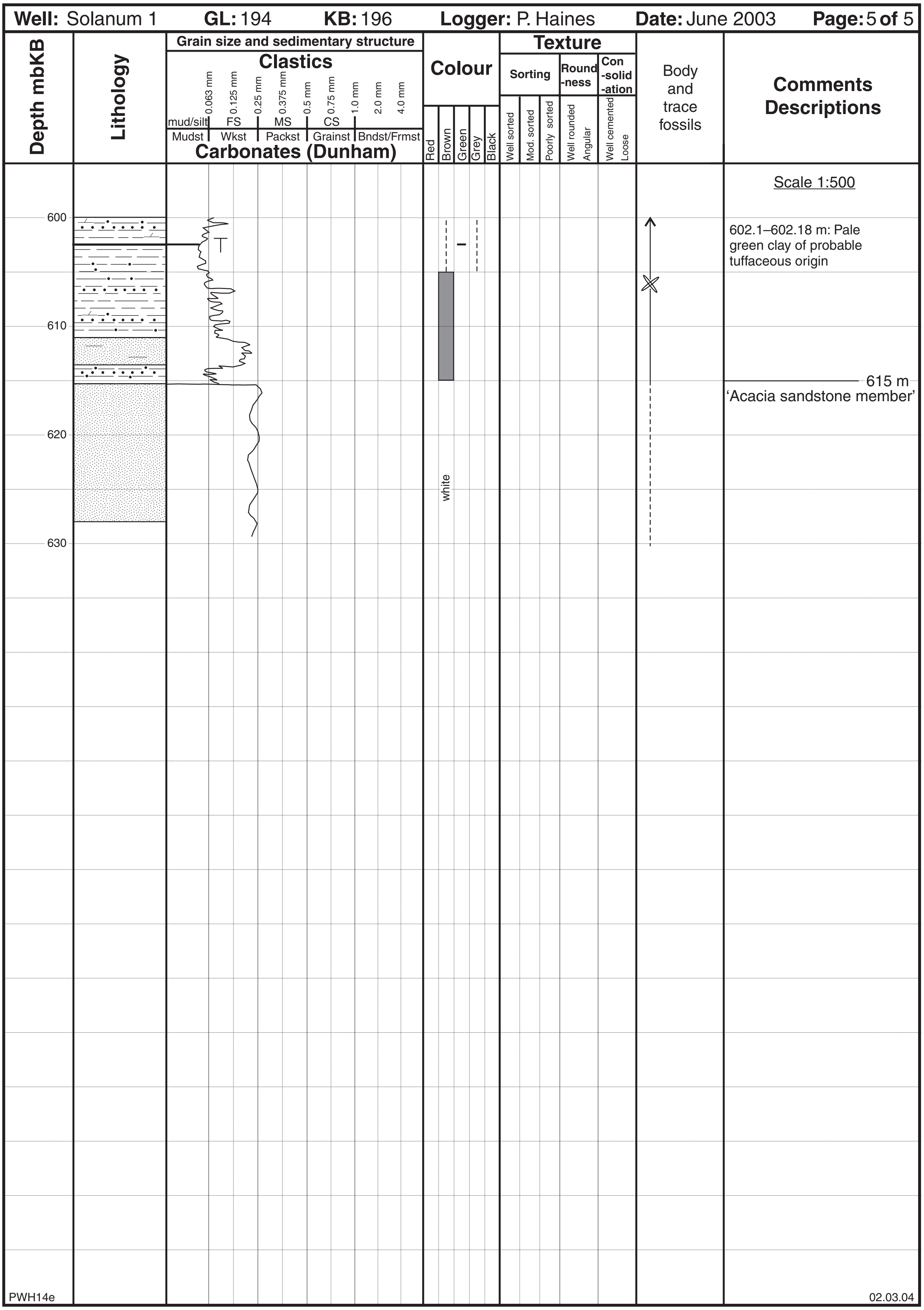

Well: Percival 1
GL: 269.6 m
RT: 274.6 m
Logger: P. Haines
Date: June 2003
Page: 1 of 1
Depth mbKB
Lithology
Grain size and sedimentary structure
Clastics
0.063 mm
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt
FS
MS
CS
Mudst
Wkst
Packst
Grainst
Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Well sorted
Mod. sorted
Poorly sorted
Round-ness
Well rounded
Angular
Con-solid-ation
Well cemented
Loose
Body and trace fossils
Comments
Scale 1:500
2020 m
2030 m
2040 m
2050 m
2060 m
2070 m
Top of core
2026.5 m
Nita Formation
2033 m
WMC unit 4
2049 m
WMC unit 3
2069.4 m
Base of core
PWH13
24.03.04


Well: Solanum 1
GL: 194
KB: 196
Logger: P. Haines
Date: June 2003
Page: 1 of 5
Depth mbKB
Lithology
Grain size and sedimentary structure
Clastics
0.063 mm
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt
FS
MS
CS
Mudst
Wkst
Packst
Grainst
Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Well sorted
Mod. sorted
Poorly sorted
Round -ness
Well rounded
Angular
Con -solid -ation
Well cemented
Loose
Body and trace fossils
Comments
Scale 1:500
Bongabinni Formation
223 m
Nita Formation
284 m
Goldwyer Formation
WMC unit 4
210
220
230
240
250
260
270
280
290
300
PWH14a
04.02.04

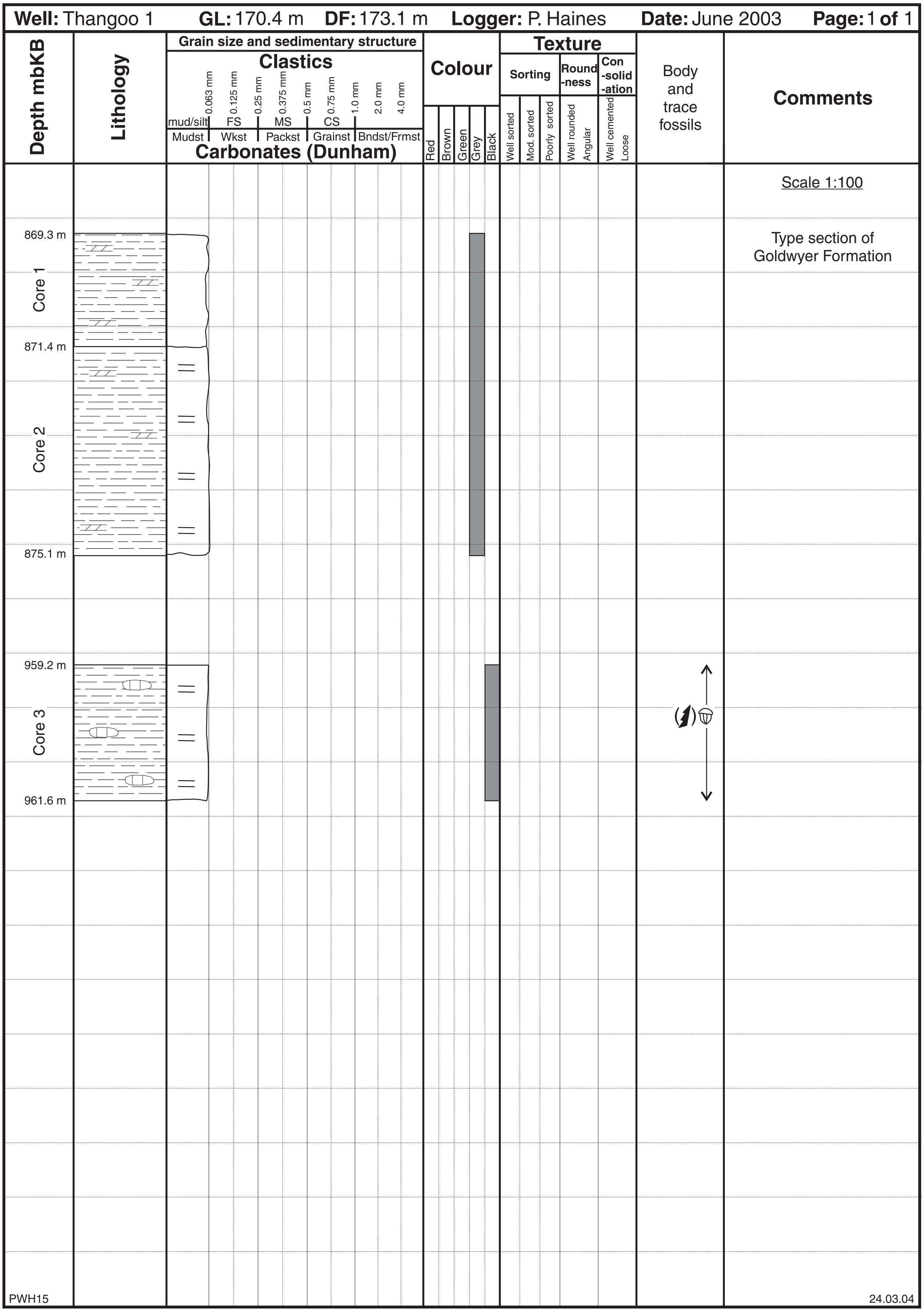

Well: Solanum 1
GL: 194
KB: 196
Logger: P. Haines
Date: June 2003
Page: 2 of 5
Depth mbKB
Lithology
Grain size and sedimentary structure
Clastics
0.063 mm
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt
FS
MS
CS
Mudst
Wkst
Packst
Grainst
Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Well sorted
Mod. sorted
Poorly sorted
Round -ness
Well rounded
Angular
Con -solid -ation
Well cemented
Loose
Body and trace fossils
Comments
Scale 1:500
300
310
320
330
340
350
360
370
380
390
317 m
WMC unit 3
395 m
WMC unit 2
PWH14b
30.12.03

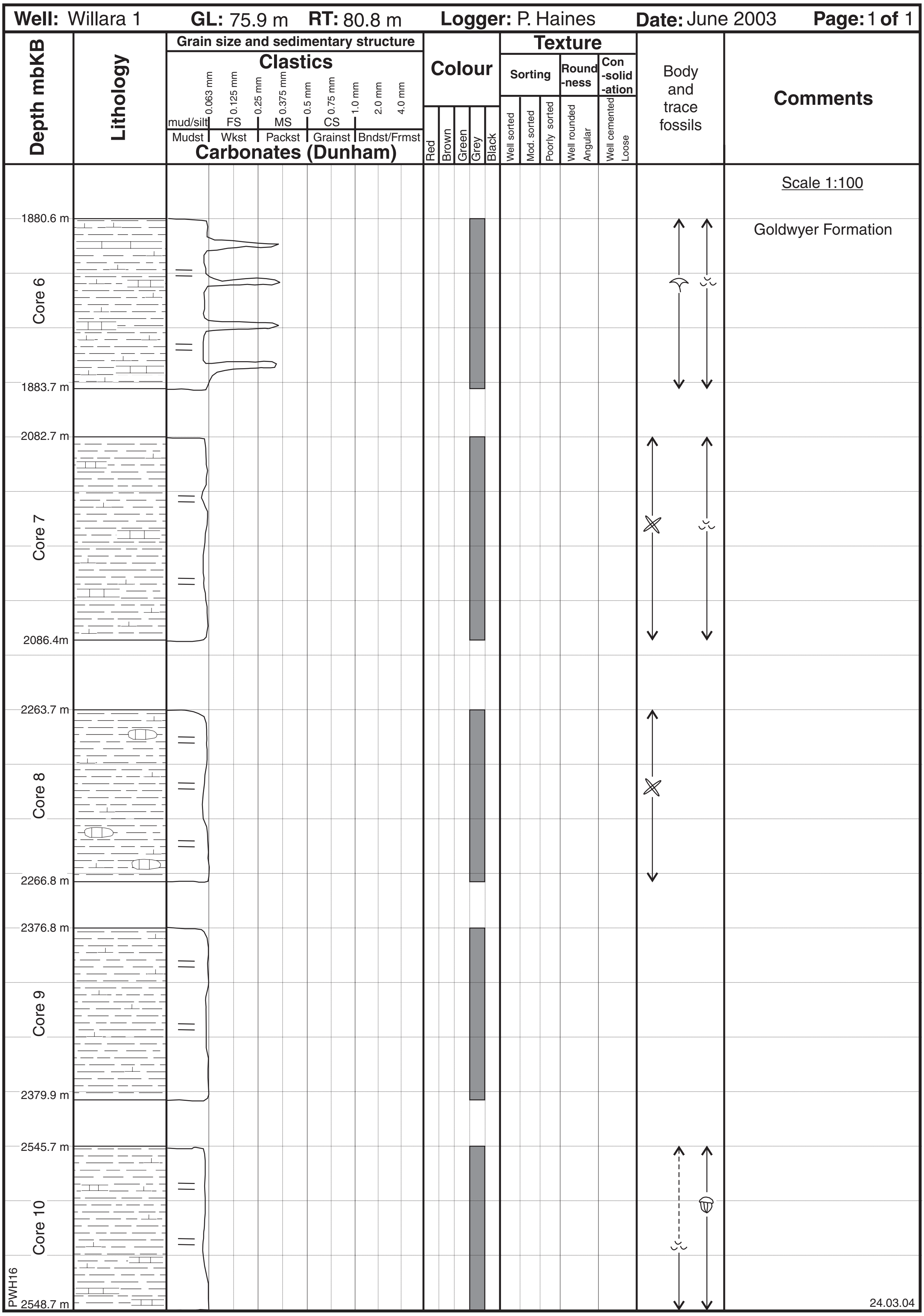

Well: Solanum 1
GL: 194
KB: 196
Logger: P. Haines
Date: June 2003
Page: 3 of 5
Depth mbKB
Lithology
Grain size and sedimentary structure
Clastics
0.063 mm
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt
FS
MS
CS
Mudst
Wkst
Packst
Grainst
Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Well sorted
Mod. sorted
Poorly sorted
Round -ness
Well rounded
Angular
Con -solid -ation
Well cemented
Loose
Body and trace fossils
Comments Descriptions
Scale 1:500
400
410
420
430
440
450
460
470
480
490
460 m
WMC unit 1
PWH14c
30.12.03

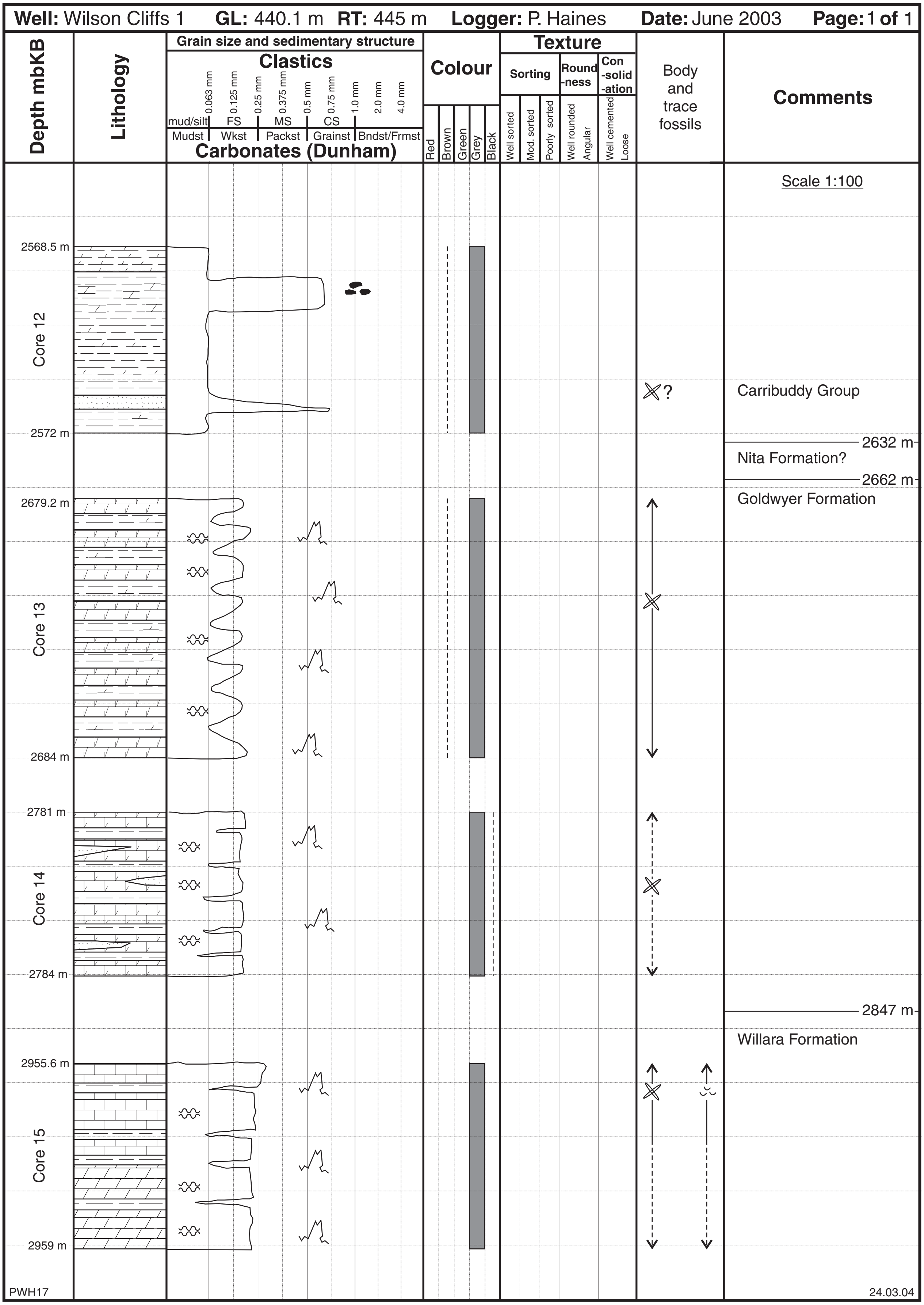

Well: Solanum 1
GL: 194
KB: 196
Logger: P. Haines
Date: June 2003
Page: 4 of 5
Depth mbKB
Lithology
Grain size and sedimentary structure
Clastics
0.063 mm
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt
FS
MS
CS
Mudst
Wkst
Packst
Grainst
Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Well sorted
Mod. sorted
Poorly sorted
Round -ness
Well rounded
Angular
Con -solid -ation
Well cemented
Loose
Body and trace fossils
Comments
Scale 1:500
500
510
520
530
540
550
560
570
580
590
563 m
Willara Formation
577.5 m: 3 cm green clay probably of tuffaceous origin
PWH14d
30.12.03



Well: Solanum 1
GL: 194
KB: 196
Logger: P. Haines
Date: June 2003
Page: 5 of 5
Depth mbKB
Lithology
Grain size and sedimentary structure
Clastics
0.063 mm
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt
FS
MS
CS
Mudst
Wkst
Packst
Grainst
Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Well sorted
Mod. sorted
Poorly sorted
Round-ness
Well rounded
Angular
Con-solid-ation
Well cemented
Loose
Body and trace fossils
Comments Descriptions
Scale 1:500
600
610
620
630
602.1–602.18 m: Pale green clay of probable tuffaceous origin
615 m
'Acacia sandstone member'
white
PWH14e
02.03.04


Well: Thangoo 1
GL: 170.4 m
DF: 173.1 m
Logger: P. Haines
Date: June 2003
Page: 1 of 1
Depth mbKB
Lithology
Grain size and sedimentary structure
Clastics
0.063 mm
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt
FS
MS
CS
Mudst
Wkst
Packst
Grainst
Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Well sorted
Mod. sorted
Poorly sorted
Round -ness
Well rounded
Angular
Con -solid -ation
Well cemented
Loose
Body and trace fossils
Comments
Scale 1:100
869.3 m
Core 1
871.4 m
Core 2
875.1 m
959.2 m
Core 3
961.6 m
Type section of Goldwyer Formation
PWH15
24.03.04


Well: Willara 1
GL: 75.9 m
RT: 80.8 m
Logger: P. Haines
Date: June 2003
Page: 1 of 1
Depth mbKB
Lithology
Grain size and sedimentary structure
Clastics
0.063 mm
0.125 mm
0.25 mm
0.375 mm
0.5 mm
0.75 mm
1.0 mm
2.0 mm
4.0 mm
mud/silt
FS
MS
CS
Mudst
Wkst
Packst
Grainst
Bndst/Frmst
Carbonates (Dunham)
Colour
Red
Brown
Green
Grey
Black
Texture
Sorting
Well sorted
Mod. sorted
Poorly sorted
Round -ness
Well rounded
Angular
Con -solid -ation
Well cemented
Loose
Body and trace fossils
Comments
Scale 1:100
Goldwyer Formation
1880.6 m
Core 6
1883.7 m
2082.7 m
Core 7
2086.4m
2263.7 m
Core 8
2266.8 m
2376.8 m
Core 9
2379.9 m
2545.7 m
Core 10
PWH16
2548.7 m
24.03.04


Well: Wilson Cliffs 1 GL: 440.1 m RT: 445 m Logger: P. Haines Date: June 2003 Page: 1 of 1
Depth mbKB
Lithology
Grain size and sedimentary structure
Clastics
0.063 mm 0.125 mm 0.25 mm 0.375 mm 0.5 mm 0.75 mm 1.0 mm 2.0 mm 4.0 mm
mud/silt FS MS CS
Mudst Wkst Packst Grainst Bndst/Frmst
Carbonates (Dunham)
Colour
Red Brown Green Grey Black
Texture
Sorting
Well sorted Mod. sorted Poorly sorted
Round -ness
Well rounded Angular
Con -solid -ation
Well cemented Loose
Body and trace fossils
Comments
Scale 1:100
2568.5 m
Core 12
2572 m
Carribuddy Group
2632 m
Nita Formation?
2662 m
Goldwyer Formation
2679.2 m
Core 13
2684 m
2781 m
Core 14
2784 m
2847 m
Willara Formation
2955.6 m
Core 15
2959 m
PWH17
24.03.04

HAINES

Depositional facies and regional correlations of the Ordovician Goldwyer and Nita Formations, Canning Basin, Western Australia, with implications for petroleum exploration

RECORD 2004/7

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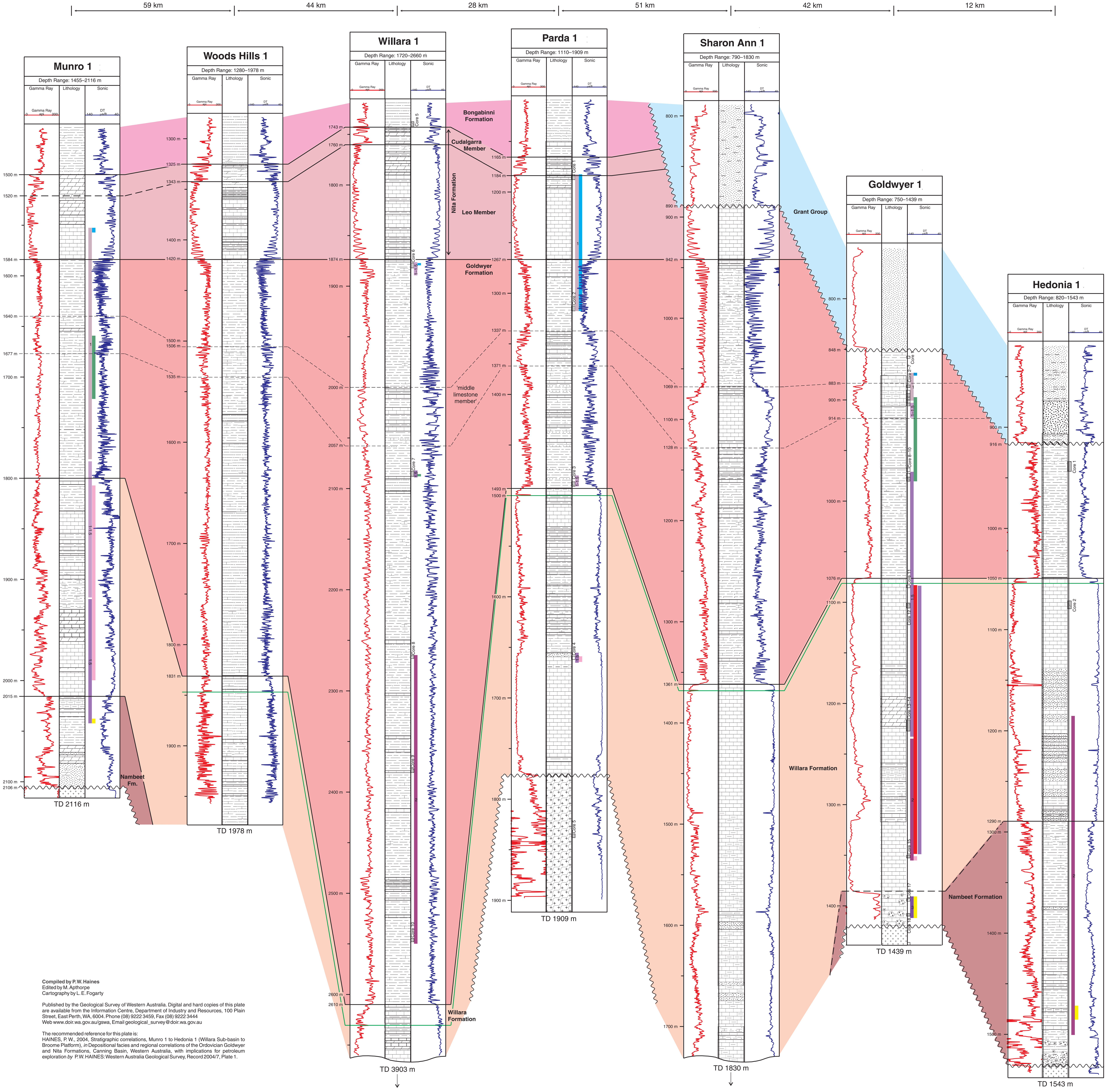

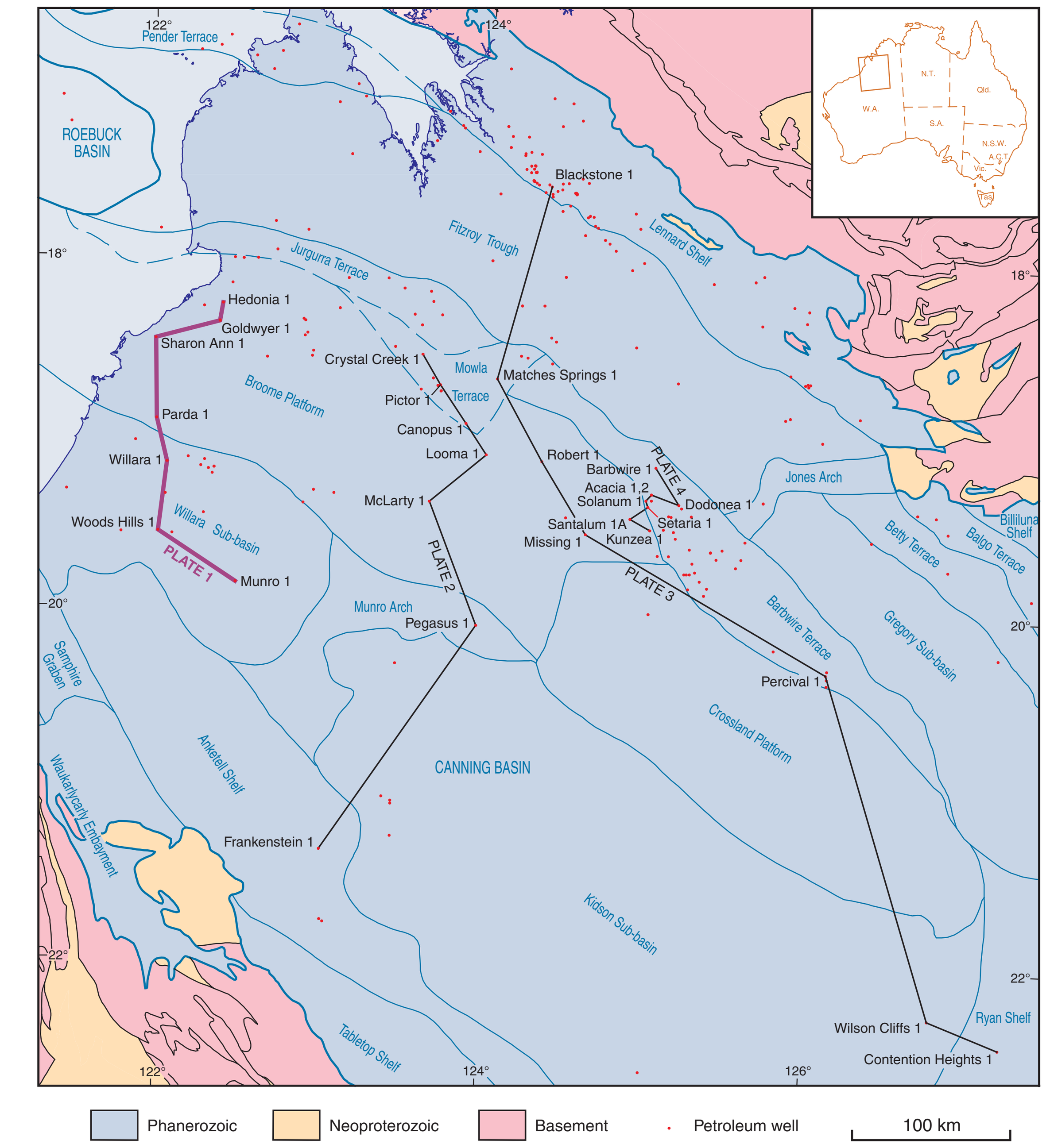

PERIOD / EPOCH		CONODONT ZONES
ORDOVICIAN	CARADOC	
	LLANVIRN	*Phragmodus–Plectodina*
		Histiodella holodentata
	ARENIG	*Histiodella altifrons*
		Jumudontus gananda
		Oepikodus communis
		Prioniodus elegans – Bergstroemognathus extensus
		Drepanoistodus
	TREMADOC	

Note: Where an age is 'undifferentiated zone x to zone y', both zone colours are shown in an expanded column width

CONODONT ALTERATION INDEX
1
1 – 1.5
1.5
2
2 – 3
3

- Conglomerate
- Pebbly sandstone
- Sandstone
- Siltstone
- Shale, claystone
- Sandy limestone
- Sandy dolostone
- Argillaceous or silty limestone
- Argillaceous or silty dolostone
- Limestone
- Dolostone
- Calcareous
- Dolomitic
- Limestone or dolostone interbeds
- Halite
- Anhydrite or gypsum
- Glauconitic
- Granitic basement
- Metamorphic basement
- Unconformity
- Interpreted correlation of formal geological unit
- Tentative correlation of formal geological unit
- Tentative correlation of informal geological unit
- ?Ash bed
- Granitic pebbles – clasts

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Edited by M. Apthorpe
Cartography by L. E. Fogarty

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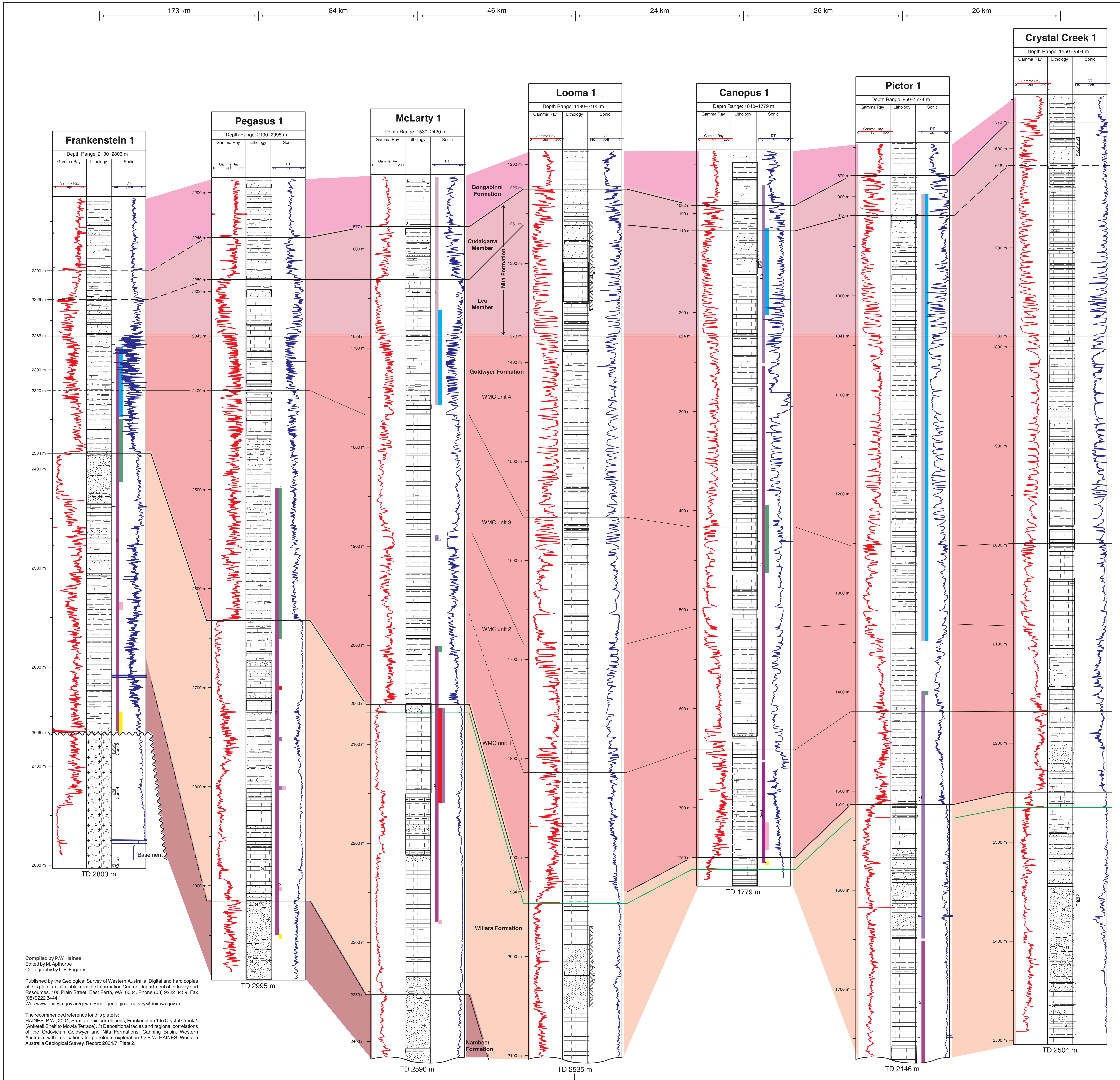
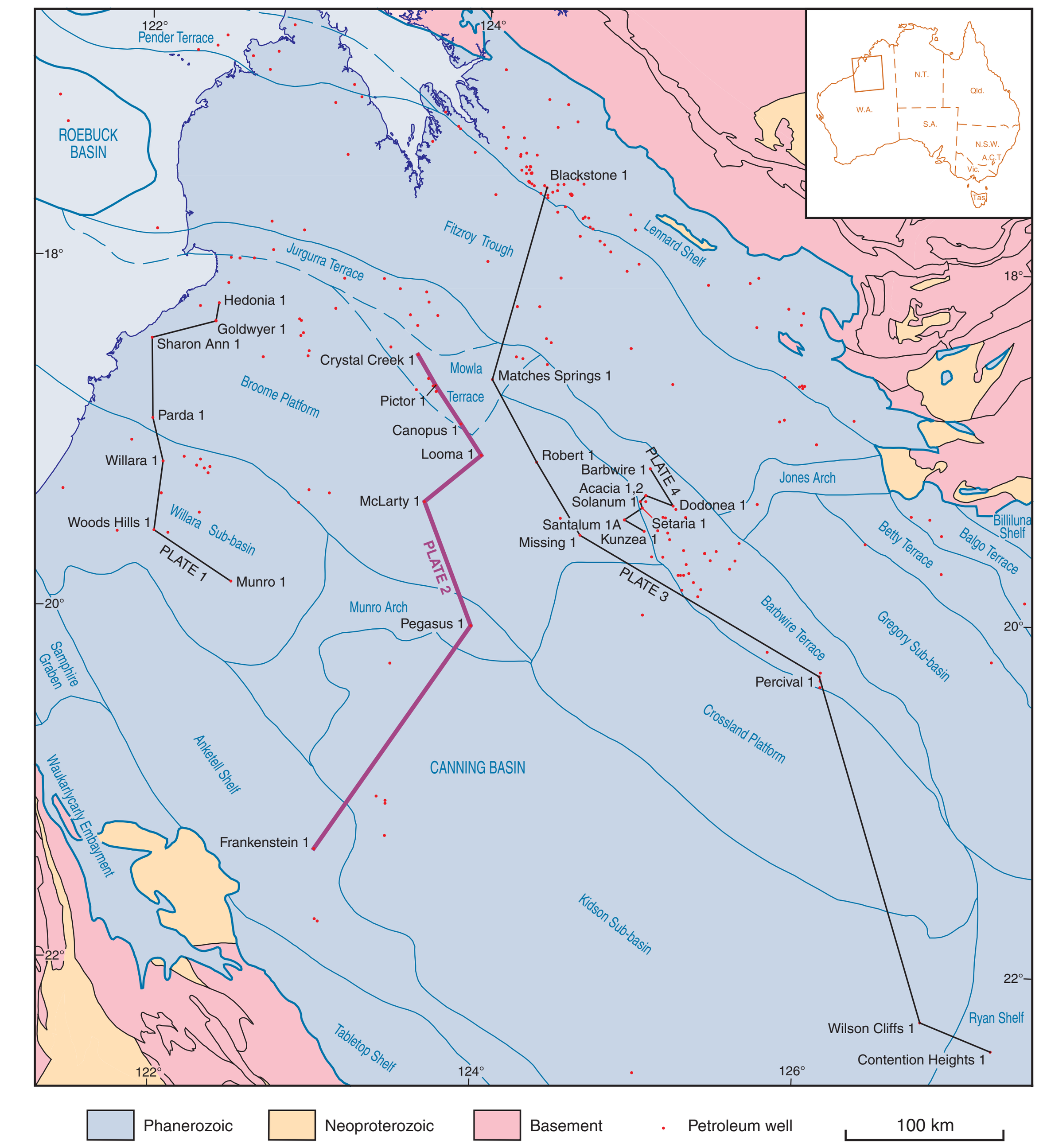
TIM GRIFFIN
DIRECTOR

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
RECORD 2004/7 PLATE 1

STRATIGRAPHIC CORRELATIONS, MUNRO 1 TO HEDONIA 1 (WILLARA SUB-BASIN TO BROOME PLATFORM)

PWH19 21.06.04





PERIOD / EPOCH		CONODONT ZONES
ORDOVICIAN	CARADOC	
	LLANVIRN	*Phragmodus–Plectodina*
		Histiodella holodentata
	ARENIG	*Histiodella altifrons*
		Jumudontus gananda
		Oepikodus communis
		Prioniodus elegans – Bergstroemognathus extensus
		Drepanoistodus
	TREMADOC	

Note: Where an age is 'undifferentiated zone x to zone y', both zone colours are shown in an expanded column width

CONODONT ALTERATION INDEX
1
1 – 1.5
1.5
2
2 – 3
3

- Conglomerate
- Pebbly sandstone
- Sandstone
- Siltstone
- Shale, claystone
- Sandy limestone
- Sandy dolostone
- Argillaceous or silty limestone
- Argillaceous or silty dolostone
- Limestone
- Dolostone
- Calcareous
- Dolomitic
- Limestone or dolostone interbeds
- Halite
- Anhydrite or gypsum
- Glauconitic
- Granitic basement
- Metamorphic basement
- Unconformity
- Interpreted correlation of formal geological unit
- Tentative correlation of formal geological unit
- Interpreted correlation of informal geological unit
- Tentative correlation of informal geological unit
- ?Ash bed

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Cartography by L. E. Fogarty

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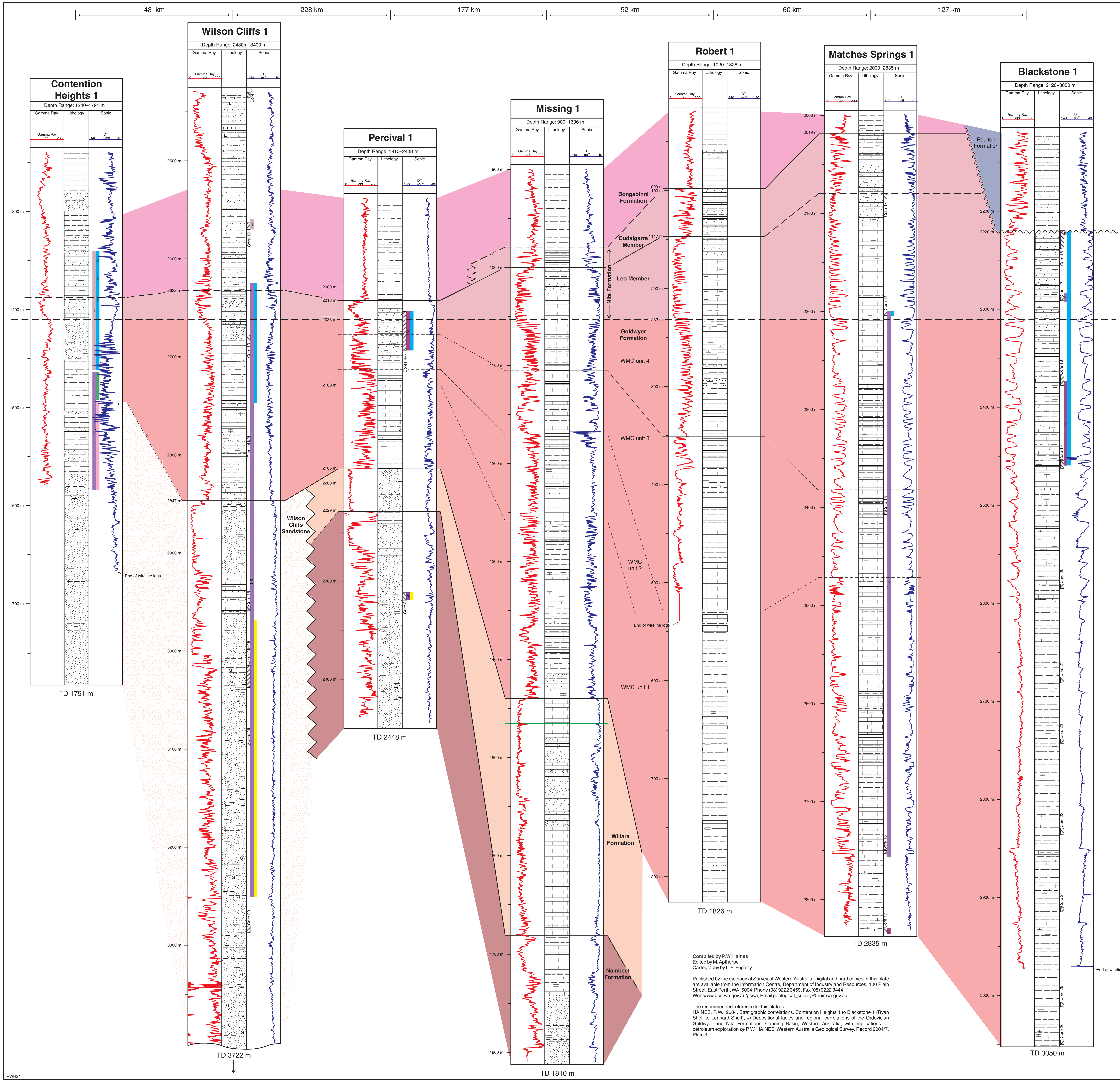
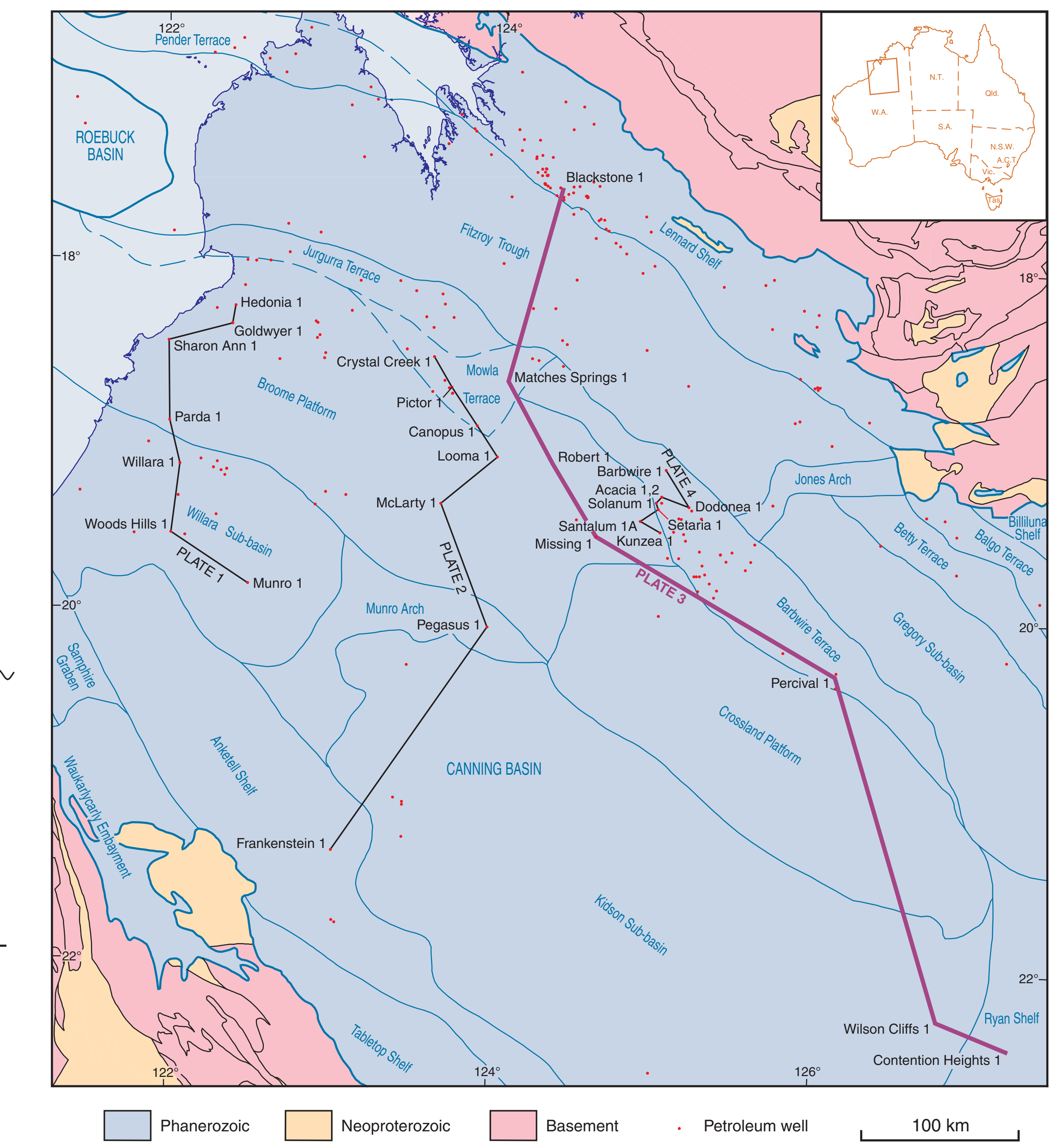
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
RECORD 2004/7 PLATE 2

STRATIGRAPHIC CORRELATIONS, FRANKENSTEIN 1 TO CRYSTAL CREEK 1 (ANKETELL SHELF TO MOWLA TERRACE)





PERIOD / EPOCH		CONODONT ZONES
ORDOVICIAN	CARADOC	
	LLANVIRN	*Phragmodus–Plectodina*
		Histiodella holodentata
	ARENIG	*Histiodella altifrons*
		Jumudontus gananda
		Oepikodus communis
		Prioniodus elegans – Bergstroemognathus extensus
		Drepanoistodus
	TREMADOC	

Note: Where an age is 'undifferentiated zone x to zone y', both zone colours are shown in an expanded column width

CONODONT ALTERATION INDEX
1
1 – 1.5
1.5
2
2 – 3
3

- Conglomerate
- Pebbly sandstone
- Sandstone
- Siltstone
- Shale, claystone
- Sandy limestone
- Sandy dolostone
- Argillaceous or silty limestone
- Argillaceous or silty dolostone
- Limestone
- Dolostone
- Calcareous
- Dolomitic
- Limestone or dolostone interbeds
- Halite
- Anhydrite or gypsum
- Glauconitic
- Granitic basement
- Metamorphic basement
- Unconformity
- Interpreted correlation of formal geological unit
- Tentative correlation of formal geological unit
- Interpreted correlation of informal geological unit
- Tentative correlation of informal geological unit
- ?Ash bed

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The recommended reference for this plate is:
HAINES, P. W., 2004, Stratigraphic correlations, Contention Heights 1 to Blackstone 1 (Ryan Shelf to Lennard Shelf), *in* Depositional facies and regional correlations of the Ordovician Goldwyer and Nita Formations, Canning Basin, Western Australia, with implications for petroleum exploration *by* P. W. HAINES: Western Australia Geological Survey, Record 2004/7, Plate 3.

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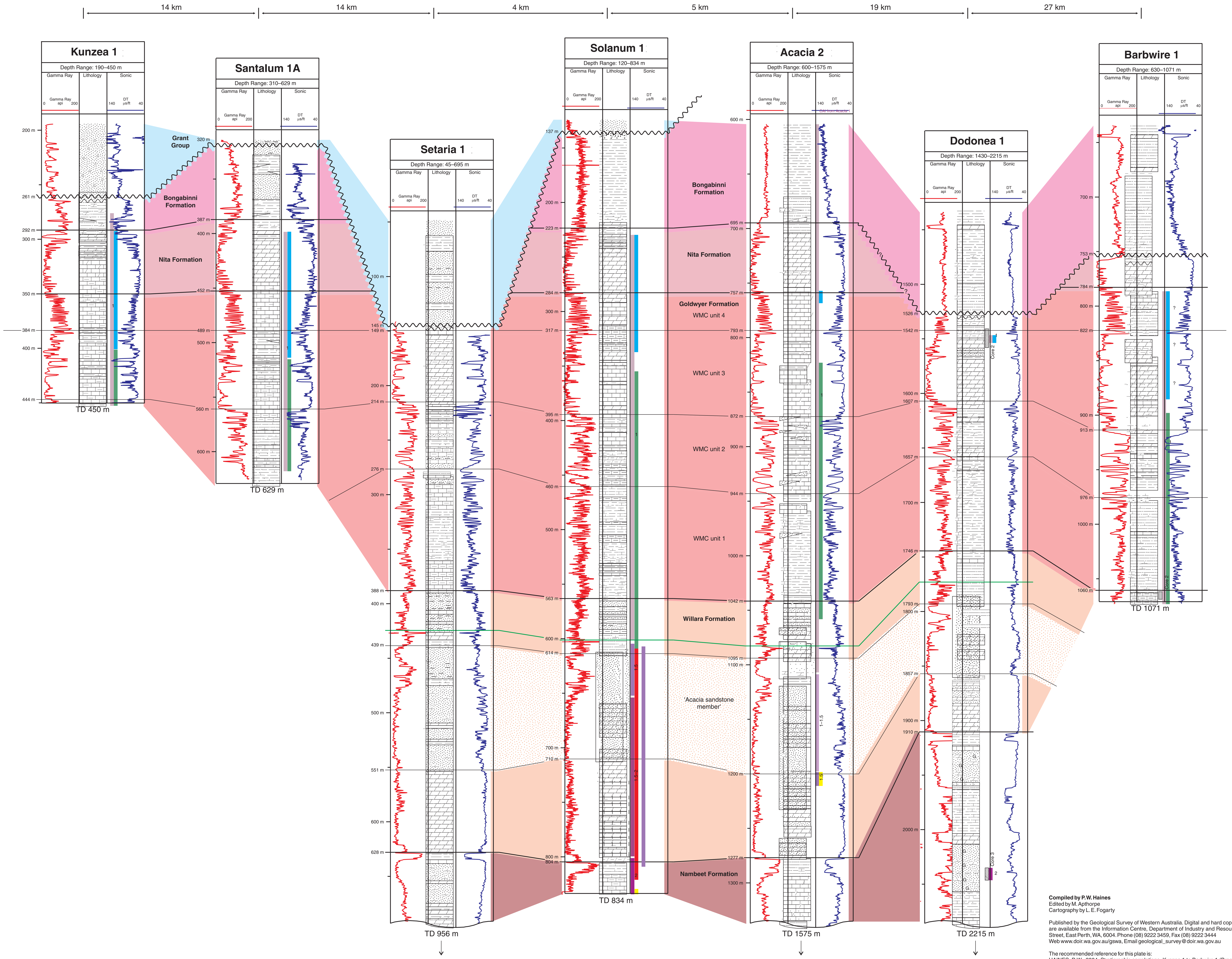
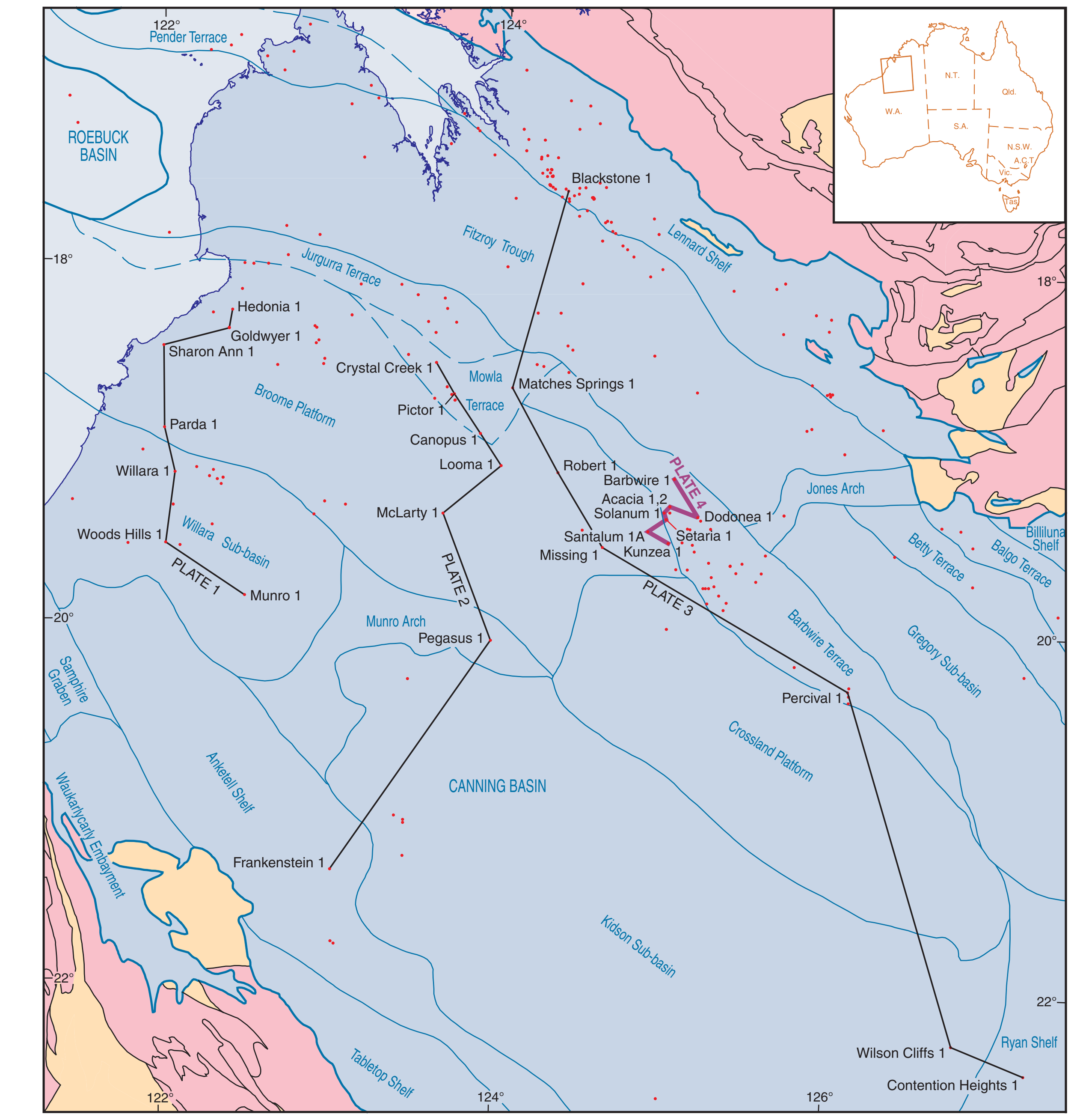
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
RECORD 2004/7 PLATE 3

STRATIGRAPHIC CORRELATIONS, CONTENTION HEIGHTS 1 TO BLACKSTONE 1 (RYAN SHELF TO LENNARD SHELF)

PWH21

21.06.04





Phanerozoic | Neoproterozoic | Basement | Petroleum well | 100 km

PERIOD / EPOCH		CONODONT ZONES
ORDOVICIAN	CARADOC	
	LLANVIRN	*Phragmodus–Plectodina*
		Histiodella holodentata
	ARENIG	*Histiodella altifrons*
		Jumudontus gananda
		Oepikodus communis
		Prioniodus elegans – Bergstroemognathus extensus
		Drepanoistodus
	TREMADOC	

Note: Where an age is 'undifferentiated zone x to zone y', both zone colours are shown in an expanded column width

CONODONT ALTERATION INDEX
1
1 – 1.5
1.5
2
2 – 3
3

- Conglomerate
- Pebbly sandstone
- Sandstone
- Siltstone
- Shale, claystone
- Sandy limestone
- Sandy dolostone
- Argillaceous or silty limestone
- Argillaceous or silty dolostone
- Limestone
- Dolostone
- Calcareous
- Dolomitic
- Limestone or dolostone interbeds
- Halite
- Anhydrite or gypsum
- Glauconitic
- Granitic basement
- Metamorphic basement
- Unconformity
- Interpreted correlation of formal geological unit
- Tentative correlation of formal geological unit
- Interpreted correlation of informal geological unit
- ?Ash bed

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The recommended reference for this plate is:
HAINES, P. W., 2004, Stratigraphic correlations, Kunzea 1 to Barbwire 1 (Broome Platform to Barbwire Terrace), *in* Depositional facies and regional correlations of the Ordovician Goldwyer and Nita Formations, Canning Basin, Western Australia, with implications for petroleum exploration *by* P.W. HAINES: Western Australia Geological Survey, Record 2004/7, Plate 4.

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
RECORD 2004/7 PLATE 4

STRATIGRAPHIC CORRELATIONS, KUNZEA 1 TO BARBWIRE 1
(BROOME PLATFORM TO BARBWIRE TERRACE)

PWH22 14.06.04